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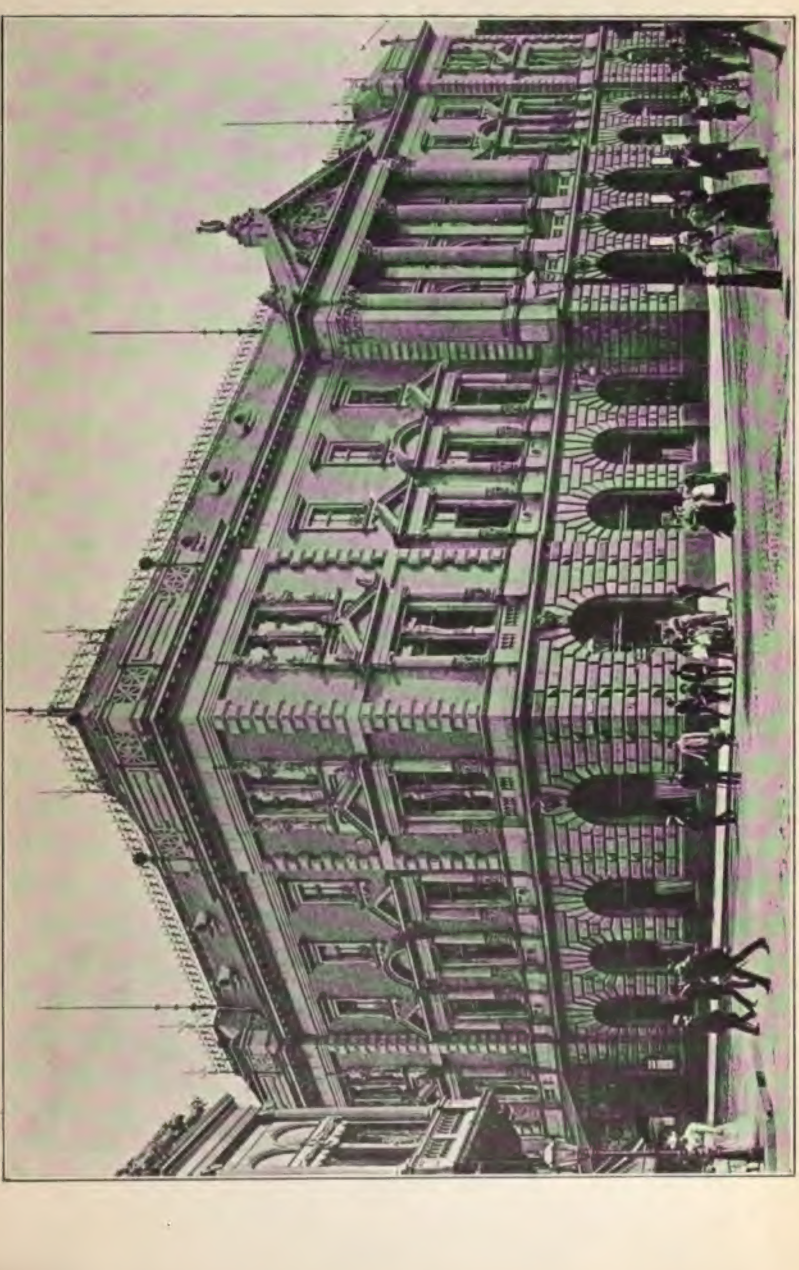

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THE JOURNAL

OF THE

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EDITED BY

BENNETT H. BROUGH

SECRETARY

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acquired an international character, and it now included the leading men of science and practice of all countries. The Exhibition afforded a striking proof of the remarkable progress of the iron and steel industry in the last twenty-two years, and the development of this great industry might be regarded as an indication of the economic culture of the country. The importance of the work carried on by the Iron and Steel Institute was realised by his Government, and he therefore expressed the hope that their discussions at Düsseldorf might result in mutual benefit. He cordially desired that their visit to Düsseldorf might be an agreeable one, and that they would long retain in pleasant remembrance the days spent in that city. In the name of his Government he therefore once more bid them a hearty welcome.

Mr. LUDWIG FEISTEL, the Deputy Mayor of Düsseldorf, next spoke in the name of the city of Düsseldorf. He expressed his satisfaction that they again had the honour of welcoming the Iron and Steel Institute. To him this was especially gratifying, as it had also been his privilege in the year 1880 to bid the members of the Institute welcome. At that date Düsseldorf had only 90,000 inhabitants, against 230,000 now. Then the iron and steel industry had just recovered from the depression of 1874 and the following years; now it was vigorous and many-sided. In 1880 Düsseldorf, in spite of its proximity to the Rhine, lacked an easy and economical communication with the river, but this was now provided for by the completion of the harbour and docks. He trusted that the members of the Iron and Steel Institute would feel themselves at home in Düsseldorf on meeting with their fellow-workers, eminent leaders of industry and men of brilliant reputation to whose efforts they owed the extensive and admirable Exhibition of the present year, and that mutual benefit might be derived from an exchange of ideas. Indeed the visits to foreign countries of technical societies consisting of the proprietors and managers of the largest works, of men of wide knowledge and experience and of far-seeing mind, might exercise an influence reaching far beyond that due to technical intercourse. Such visits afforded an opportunity for discussing freely and in a friendly manner subjects

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listen to the representative of the German Government, who had given them so cordial a welcome to Düsseldorf. The Institute had been there in 1880, when they had a large gathering of members, and now it was his proud privilege to lead their present members to Düsseldorf again. They had come to Düsseldorf to learn; they had come feeling sure that they would see a great deal that would interest and instruct them, and would inform them wonderfully also. What they had seen already had satisfied them of the splendid developments of German industry since they last met in that exceedingly prosperous country. It was many years since he first came to Germany in connection with the fire-brick stoves of his brother, Thomas Whitwell, who was known to very many of them, and who was highly esteemed by those who knew him; and he was glad to say that he had always been received as a friend. He never visited their works without experiencing a kindly reception and a welcome everywhere. As an Institute, they were aware that they had visited many countries. They had striven as far as possible to instruct and enlighten their members, and he felt that day if they went back to England, to France, Austria, Sweden, Belgium, Styria, or America without receiving enlightenment the fault would be their own, for so far as he could see everything was being thrown open to them by the heads of the different works. He could heartily assure their younger members of the extreme gratification he felt, as their President that day, because he knew that they would go home to England with their minds brightened, enlightened and enlivened by what they saw in and around Düsseldorf. They were not among an effete people; they were not among a people they could show anything to. The German people were keenly alive to the necessity of educating their youth, and of giving them a practical knowledge when they had grown to manhood. England had the greatest possible sympathy with Germany, and the greatest possible appreciation of their ability to compete with England in business. But it was an honourable competition. It would be their own fault if they did not take advantage of what they saw, and perhaps to teach their own boys the lessons learnt on the present occasion. There was a wonderful Exhibition now open, one at any rate that had opened his eyes to the perfection of steel workmanship.

Name.	Address.	Proposers.
Cooper, Frank William	Erdely, Middlesbrough	David Evans, J. E. Stead, Arthur Cooper.
Davies, Robert William	Elton House, Darlington	W. Thackray, George Ainsworth, John W. Spencer.
Denny, Thomas James	29 Great George Street, London, S.W.	George Cawley, James Riley, Henry Peech.
Dougall, James Dick .	27 Guard Street, Workington, Cumberland	James Duffield, R. E. Higton, John Paterson.
Dower, Robert Smith	63 Tennyson Avenue, Bridlington, Yorks	Arthur Horsfield, Leason Gray, T. B. Loxley.
Downing, Nicholas .	Victoria Avenue, Norton Road, Stockton-on-Tees	John T. Gaunt, James Bott, Richard Gaunt.
Durrant, William Thomas	Orwell Works, Ipswich	H. S. Jefferies, William Whitwell, Sir Theodore Fry.
Fellows, John . . .	Clyde Works, Cradley Heath, Staffs.	James Donechay, Alfred Colley, W. Moore.
Freeth, *Captain* Chas. John D., B.A., R.A.	8 Royal Arsenal, Woolwich	R. A. Hadfield, I. B. Milne, P. B. Brown.
Gibson, Thomas Smurfitt	122 Cannon Street, London, E.C.	H. Le Neve Foster, Fred Mills, James J. Wallis.
Grey, Henry	Ecke Königsringe, Luxemburg	James Roberts, Harry Silvester, John W. Hall.
Hamilton, James . .	6 Kyle Park, Uddingston, Scotland	John R. Cross, William Clark, J. Jackson.
Heald, George Thomas	"Adlington," 181 Cathedral Road, Cardiff	William Evans, Enoch James, Gething Lewis.
Hole, Robert S. . . .	Tawton Rectory, North Tawton, Devon	Lt.-Col. Reginald H. Mahon, William Whitwell, Sir W. C. Roberts-Austen.
Hughes, Herbert William	188 Wolverhampton Street, Dudley	G. H. Claughton, Sir Benjamin Hingley, George Macpherson.
Hüssener, Albert . .	Maxstrasse 8, Essen, Germany	Hugh Bell, W. H. Panton, C. Lowthian Bell.
Hüssener, Kurt . . .	Maxstrasse 8, Essen, Germany	Hugh Bell, C. Lowthian Bell, W. H. Panton.
Jacks, Thomas William M., M.I.M.E., Assoc. M.I.C.E.	Hillside, Wednesbury .	Harry B. Toy, W. Moore, Walter Macfarlane.
Jefferson, Joseph, A.R.S.M.	Empreza Industrial Portugueza, Santo Amaro, Lisbon	J. O. Arnold, H. Marsden, A. McWilliam.
Last, Frank Bernard .	Landore, R.S.O., South Wales	John R. Wright, E. Windsor Richards, John Paton.
Lee, Cecil Robert . .	Arthur Lee & Sons, Ltd., Sheffield	Arthur Lee, Albert Senior, Arthur S. Lee.
Lindley, Herbert . .	Pear Tree Cottage, Altrincham, Cheshire	Arthur Cooper, Sir Richard Mottram, Arthur W. Galloway.
Macnab, Thomas Pollock	Lyme View, Romiley, near Stockport	Joseph Adamson, Henry Webb, Myles Cooper.
Meier, Max	Differdingen, Luxemburg	David Evans, J. E. Stead, James Campbell.

Name.	Address.	Proposers.
Wing, William . . .	Ashdell, Broomhill, Sheffield	Arthur Lee, Joseph Young, Albert Senior.
Woof, George Edward	The Orconera Iron Ore Company, Limited, Apartado 42, Bilbao	Sir David Dale, Edward P. Martin, August Reichwald.
Wright, William Charles	7 St. James' Gardens, Swansea	Isaac Butler, John R. Wright, Fred Mills.
Ybarra, Fernando M. de	Compañia de los "Altos Hornos de Vizcaya," Bilbao	Edward P. Martin, Sir David Dale, August Reichwald.

The President-Elect.

The President said it had been necessary to consider who was to be their new President—who was to succeed himself in May 1903. It would be a very great pleasure to those present to hear him announce that the Council had selected their Vice-President, Mr. Andrew Carnegie, the former American ironmaster, but now a resident of Skibo Castle in Scotland, to take the presidency of the Iron and Steel Institute for the next two years. He need hardly remind English members how much they owed to Mr. Andrew Carnegie in encouraging their youth to obtain exact knowledge by giving them, first a gift of £6500, and when that was not enough a second gift of £6500, to help them to investigate matters of interest to the iron and steel industry. Andrew Carnegie, as they knew, was a name which in America was highly honoured, and in England and Scotland and many other iron- and steel-making countries also; and he was doing at the present time a very great deal educationally for them. He had given immense sums of money for the foundation of libraries and institutes, for the teaching and training of the youth of many districts.

Retiring Members of Council.

The Secretary announced that, in accordance with Rule 10, the following Vice-Presidents would retire in May next: Mr. Percy C. Gilchrist, Mr. S. R. Platt, and Mr. J. D. Ellis. The following five Members of the Council would also retire: Mr. J.

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THE PROGRESS AND MANUFACTURE OF PIG IRON IN GERMANY SINCE 1880.

By W. BRÜGMANN (Dortmund).

A.—*The Economic Aspect of the Pig Iron Industry of Germany.*

A comparison of the entire world's production of pig iron (18,300,000 tons) in 1880 with that given for 1901 (over 39,000,000 tons) shows that in this period the production of pig iron has been more than doubled. Almost the whole of this increase may be apportioned between the two countries, Germany and the United States. In 1880, the United States ranked second among the iron-producing countries with a production of 3,895,000 tons, equal to half the production of Great Britain at that time, and Germany occupied the third place with 2,729,000 tons, or about one-third of the English output. In the year 1900 there were produced in America 14 million tons; in England 8·962 million tons; and in Germany 8·351 million tons. The production of the United States is therefore more than three and a half times, and that of Germany more than three times, greater at the present time than in 1880, while that of England shows but a moderate increase.

It is unnecessary at a meeting of the Iron and Steel Institute, the members of which have taken so prominent a part in finding new outlets for the use of iron and steel, to examine into the causes which have led to this rapid rise in the world's production of pig iron. Equally inappropriate would it appear to discuss fully the sudden development of the American iron industry. It may be permitted, however, to touch briefly upon the conditions which led to the vast increase in the manufacture of pig iron in Germany.

Two chief factors among many others contributed to bring about this result. In the first place, an extraordinary development in coal-mining took place which rendered available a good supply of native fuel for German blast-furnaces; secondly, the opening up of the iron ore deposits of Luxemburg and

Lorraine was necessitated by the introduction of the basic process.

Since 1880 the total coal production of Germany, which at that time amounted to about 47 million tons, has more than doubled. In round figures 100 million tons was raised in 1900. The greater part of this increase was obtained in the Ruhr district, the output rising from 22 million tons in 1880 to 60 million tons in 1900. The coal-mining industry has therefore developed in about the same proportion as the iron-making industry. In fact this district could supply the whole of the German blast-furnaces with coke, since the amount of coke produced here alone in 1900 was 9,644,000 tons, while that of the whole of Germany in the same year was 12,859,000 tons. The coke produced in other parts besides the Ruhr district amounted to—

	Million Tons.
In Upper Silesia	1·411
In Lower Silesia	0·536
In the Saar district	0·894
In the Aachen district	0·267
In the Oberkirchen district	0·033
In the Kingdom of Saxony	0·074

The discovery of the method for the dephosphorisation of iron in the converter exercised the most important influence on the rise of the German iron industry. At the meeting of the Institute at Düsseldorf in 1880 Mr. Massenez stated that—

"For a long time it appeared as if the dephosphorising of pig iron in the manufacture of steel and homogeneous iron could only be accomplished in the open-hearth, and was in the converter impossible, until the achievements of Snelus, Richards, and Thomas and Gilchrist were made known, which proved at once the possibility of dephosphorising by means of the basic process in the Bessemer converter.

"The German ironmasters, owning vast quantities of cheap phosphoric ores, but having little hæmatite at their command, had good reason to be thankful to those who, either through their good counsel or actual active service, have conduced to this result."

Notwithstanding that these words emphasise the extreme importance for the German iron industry attributed to the introduction of the basic process so soon after its discovery, yet

it could hardly have been anticipated at that time that Germany would in twenty years' time be producing over 4,800,000 tons of basic pig iron, or about 2 million tons more than the total iron production of 1880.

Simultaneously with the basic pig iron the manufacture of foundry pig in Germany has also greatly increased—that is to say, from 200,000 tons in 1880 to 1½ million tons in 1900. In the meantime Germany has become able to supply her own requirements as regards foundry pig.

The manufacture of puddling iron and spiegel has declined from about 2 million tons to 1·6 million tons. Unfortunately the statistics do not give separate details of these two varieties of iron, otherwise a considerable variation in the amount of each would be noticeable. The production of wrought iron sank from 2 million tons in 1880 to 1·2 million tons in 1895. Since then it rose to 1·8 million tons. The production of Bessemer pig has experienced comparatively unimportant fluctuations, amounting to about half a million tons.

Notwithstanding the unprecedented development of the German iron industry, the blast-furnace works of the country have not been able to meet the demand. In the last ten years, 1891 to 1900, the excess imports have amounted to 1·8 million tons of pig and scrap iron. It must, however, be borne in mind here that the favourable condition of the iron industry during the last few years has had much to do with this, since of that quantity more than 1 million tons was imported during the two years 1899 and 1900. It is probable, however, that in the succeeding years a change will occur, since in 1901 the exports exceeded the imports by 100,000 tons, and in the first half of 1902 by 330,000 tons.

Before passing to the discussion of the distribution according to locality of the iron-making industry, the question of the ore supply of Germany may be briefly reviewed. In discussing this subject, Dr. H. Wedding states: "On calculating how far the needs of the individual countries can be met by their own ore supply, it will be seen that only the United States and Germany have a sufficient supply of iron ore to enable them to manufacture their pig iron without the necessity of procuring supplies from abroad. In reality, however, the United States alone are

Table of Statistical Details of the Imports, Exports, and Through Transport of Iron Ore, Manganese Ore, and Cinder, available for Smelting, across the Frontier of the German Empire, during the years 1881 *to* 1900.

Year.	Imports.			Exports.			Through Transport.		
	Iron Ore.	Manganese Ore.	Cinder.	Iron Ore.	Manganese Ore.	Cinder.	Iron Ore.	Manganese Ore.	Cinder.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1881	633,642	...	419	1,450,745	...	805	7,468	640	15
1882	785,359	3,675	...	1,621,180	2,368	...	641	161	.
1883	754,728	...	...	1,784,585	...	...	...	...	...
1884	981,347	9,100	1,448	1,899,395	3,551	1,183	904	693	643
1885	852,397	..	125,538	1,771,238	...	13,892	80	...	2,967
1886	813,002	...	101,459	1,831,975	...	16,196	326	...	294
1887	1,036,603	...	167,469	1,744,937	...	39,972	386	...	297
1888	1,163,881	...	315,034	2,212,328	...	37,623	508	...	997
1889	1,252,968	...	421,128	219,015	...	39,902	18,179	...	456
1890	1,559,512	...	490,633	2,245,491	...	100,296	37,012	...	1,466
1891	1,249,221	11,413	410,870	1,973,481	1,755	19,465	29,544	741	2,292
1892	1,675,124	9,654	521,665	2,643,403	2,304	16,728	38,541	371	2,786
1893	1,573,830	12,092	477,801	2,353,398	2,687	17,412	43,349	227	3,498
1894	2,093,007	14,252	632,884	2,558,729	2,787	21,503	61,821	2,088	997
1895	2,017,135	22,575	537,542	2,480,135	4,460	20,431	88,178	3,314	421
1896	2,586,705	63,869	680,251	2,642,294	7,177	17,214	68,267	3,457	165
1897	3,185,643	86,910	670,224	3,230,390	8,615	27,722	99,088	4,031	83
1898	3,517,419	130,710	685,095	2,933,733	4,809	29,931	78.543	1,219	2,084
1899	4,218,959	196,827	892,388	3,139,207	7,040	25.564	74,664	1,184	120
1900	4,105,583	204,136	974,699	3,360,220	1,988	32,391	105,872	...	..

NOTE.—The whole of these figures represent tons of 1000 kilogrammes. The data given correspond to the official statistics of the Imperial Statistical Department.

attained after a long period of years, and even during the last twenty years it has successfully held its own, in spite of the heavy losses incurred by the works in consequence of the falling off in the production of wrought iron and the resulting depreciation of the existing installations.

In his publication on the iron industry of the Dortmund district, Mr. Tübben, *Bergassessor*, makes the following statement:—

"The far-reaching influence of the basic steel production in the course of the last twenty years upon the methods of producing pig iron is best shown by the fact that in 1880 the production of puddling iron, amounting to 352,811 tons, formed 43 per cent. of the total pig iron produced in the district. During last year (1900) not more than 56,164 tons were manufactured, representing only 2 per cent. of the total output of pig iron. In the same period the production of basic pig rose from 396,226 tons, or 48 per cent., to 2,306,056 tons, or 80·5 per cent., of the total production of iron. It must also be borne in mind that about 85 per cent. of the steel produced is made by the basic process."

The blast-furnaces of the Rhineland and Westphalia, with the exception of those at Eschweiler, use exclusively coke manufactured from the coal of the Ruhr basin. Notwithstanding that the coke is made from coal with a greatly varying coking capacity and purity, it may be characterised as a good blast-furnace coke. The ash content is about 9 per cent. and the moisture amounts to from 7 to 12 per cent. As regards its capacity to resist pressure, it may be mentioned that the experience during the last twenty years shows that furnaces 30 metres (about 100 feet) high can be worked with Ruhr coke without the least difficulty.

Most of the blast-works in the Ruhr district have their own coking plants, but these now no longer furnish the whole supply required for the works, because the collieries have fixed the price of coking coal at such a figure that the ironworks scarcely gain any advantage from making their own coke. The large iron-making firms of the coal district have, however, placed themselves in a position independent of the market by the purchase of collieries. In many cases these are in the immediate neighbourhood of the blast-works, or failing this the companies have

From the Lahn and Dill district two kinds of ore are supplied to the Ruhr region—red hæmatite with 48 to 52 per cent. of iron and fully 20 per cent. of residues, and manganese ores containing 22 to 38 per cent. of iron, 7 to 8 per cent. of manganese, and 18 to 25 per cent. of residues. These ores are conveyed a distance of about 132 miles, the freight being about 4s per ton. The price delivered for the red hæmatite is 15s. 7d., while that for manganese ores amounts to 14s. 6d. There is a considerable percentage of phosphorus in these ores, and the extraction of metal is low on account of the high proportion of residues. The hæmatite can by careful dressing be made fairly uniform in quality, but the metal content of the manganese ores fluctuates generally within somewhat wide limits. About 100,000 tons of pyrites residues are consumed, the price at the furnace being about 15s., and approximately 550,000 tons of native tap cinder are used, the latter being worth 14s. 6d. at the furnace.

At the iron mines of the Hüggel, of the Porta and of Bredelar, 400,000 tons are mined annually altogether. The use of these, as also of the ores imported from beyond sea, will be pointed out in discussing the production of the various kinds of iron.

A few general remarks may be of interest as to the routes by which the imported ores are brought in. For the Rhineland and Westphalia the Dutch ports at the mouth of the Rhine, Rotterdam and Amsterdam, are the most convenient. Nearly the whole import trade is conducted through these and recently through Emden. With a few exceptions which will be mentioned later, almost the whole of the ores imported from beyond sea are utilised in Rhenish Westphalia. The usual practice of the Rotterdam wharfingers is to negotiate the sale of ores from definite localities according to analysis, at prices which include delivery at the blast-furnace works. The ores are conveyed by water to the works situated on the Rhine, while to those in the coal district they are either brought to Ruhrort by water and thence by rail or by rail the whole way from Rotterdam. The latter route is only possible on account of the low rates granted by the Dutch railways to this kind of traffic. On account of the great volume of the consignments the ports of Rotterdam and Amsterdam obtain very favourable ocean freights, and shippers endeavour in every way to render the cost of transit

	Germany.	Rhenish Westphalia.
	Per Cent.	Per Cent.
Puddling spiegel	22·6	10·0
Bessemer pig	74·2	11·5
Basic pig	38·4	57·0
Foundry pig	43·2	21·5

Within this grouping the basic pig ranks first in importance, amounting to 57 per cent. of the whole production.

Nearly all blast-works manufacture this variety, with the exception of the Krupp works and those on the middle Rhine. Steelworks are combined with the blast-works in most cases, and the pig iron is charged in the liquid state into the converters.

According to *Bergassessor* Tübben basic pig is worked by the direct process at the following works:—

The Bochumer Verein, with 3 converters of 5 tons capacity.

Deutscher Kaiser Company, with 4 converters of 18 tons capacity.

Hoesch Steelworks, with 3 converters of 12 tons capacity.

Gutehoffnungshütte, with 4 converters of 15 tons capacity.

Hoerde Works, with 4 converters of 18 tons capacity.

Phœnix Works, with 3 converters of 12·5 tons capacity.

Rheinische Stahlwerke, with 4 converters of 8 tons capacity.

Union Company, with 4 converters of 18 tons capacity.

Basic pig is also manufactured at Schalke, the Niederrheinische Hütte, Hochdahl, Friedrich Wilhelmhütte, and Aplerbeck.

For commercial purposes this iron is manufactured with the following composition:—

Silicon.	Phosphorus.	Manganese.
Per Cent.	Per Cent.	Per Cent.
max. 1	min. 1·8	min. 2

At the works in the coal district the charges are made up as follows: 35 to 40 per cent. of minette ore; 35 to 40 per cent. of Swedish ore (Grängesberg, Gellivare); 10 per cent. of spathic ore or Nassau brown ore; 10 to 20 per cent. of various material, such as native and foreign tap cinder, Bessemer and open-hearth cinder, blackband, bog iron ore, ores from the Porta, &c.

The works on the Rhine use as high a proportion as possible

firm's foreign mines from which the Bessemer pig is manufactured. The works authorities smelt this iron at the blast-works at Rheinhausen and Hochfeld and work it up in fifteen converters, of 5 tons capacity each, at Essen. The construction of new steelworks at Rheinhausen has long been under consideration, but has not yet been carried out. Besides Krupp, the Bochumer Verein has also retained the acid process. This firm manufactures the raw material to supply three converters of 7·5 tons capacity each.

Puddling Iron and Open-Hearth Pig.—In Rhenish Westphalia about 300,000 tons were manufactured, representing 10 per cent. of the amount produced in the country, which formed 22·6 per cent. of total production of iron. In 1882, 900,000 tons were blown, of which 800,000 tons were puddling iron. In 1900 scarcely a fifth of the production was used for puddling, while four-fifths consisted of open-hearth pig. Up to the year 1896 the quantity of wrought iron produced remained about the same, on account of the prejudice against mild steel as regards untrustworthiness, inferior welding qualities, and extreme sensibility to the mode of treatment. Moreover, the mechanical appliances of the rolling mills were not everywhere capable of dealing effectively with the slabs or blooms. The rising price of coal and the increasing demands of the workmen soon limited the production, though the improvement in quality of the steel and the necessity of extensive new works were also certainly not without influence. The introduction of the brick hot-blast stoves increased the difficulties in the manufacture of the puddling iron, because the irons low in carbon and silicon formerly so much in demand were not so trustworthy as regards composition.

The composition of pig iron for the manufacture of wrought iron is about the following:—

	Per Cent.
Carbon	2 to 3
Phosphorus	0·2 to 0·3
Copper	0·2 to 0·3
Silicon	0·3 to 0·8
Manganese	2 to 6
Sulphur	0·01 to 0·04

It is blown from the most varied kinds of ore, but the Siegerland spathic ore, the Nassau hæmatite and tap cinder are almost always used.

The Niederrheinische Hütte also manufactures silicon-spiegeleisen with:—

	Per Cent.
Silicon	10 to 14
Manganese	20 to 24
Carbon	1·1 to 1·3
Phosphorus	0·12 to 0·14
Sulphur	0·018 to 0·025

Only in the case of the spiegeleisen are the native manganese ores added in manufacture; for blowing the iron with a high manganese content, ores from nearly all parts of the world are used.

The firm of William Müller & Company in Rotterdam has furnished the following tabular statement relative to the import of manganese ores:—

		Tons.
Russia, Poti	125,467	
,, Batoum	3,070	
		128,537
India, Bombay	9,980	
Brazil, Rio de Janeiro	2,954	
Turkey, Derinage	{ 1,016 2,424	
,, Dede Agatch	400	
		16,774
Total		145,311

GROUP II.—*The Siegerland, Lahn District, and the Ironworks of Hesse-Nassau.*

The kind of iron produced in this group depends entirely on the nature of the ores occurring in the locality. Foreign ores are smelted only in very small quantities. The iron manufactured in 1901 represents 8·1 per cent. of the total production of Germany, and amounts to 634,712 tons. The proportion which the various kinds bear to the whole production of the country is as follows:—

	Percentage of the Total Production of Germany.	Production of Group II. Per Cent.
Forge spiegeleisen	32·9	0·3
Bessemer pig	5·1	3·7
Basic pig	0·3	2·1
Foundry pig	10	23·8

Industrial District of the Siegerland Division of Siegen, Olpe, and Altenkirchen. Production in 1000 *tons.*

	1895.	1896.	1897.	1898.	1899.	1900.
Mild steel plates .	85·5	103·8	103·7	118	135	125·1
Mild steel blooms, slabs and forgings .	...	...	43·07	52·1	66·91	102·28
Wrought-iron plates .	2·67	1·96	1·58	1·48	1·31	1·58
Wrought-iron blooms .	...	...	23·1	35·16	29·31	29·20

From the above it would appear as if the manufacture of puddling pig could not be continued. But, as a matter of fact, over 200,000 tons, representing 35 per cent. of the production of the district, are still manufactured. The greater part of this is worked up in the district itself into merchant iron, wire, &c., and the remainder goes to the works on the Lenne and in Westphalia.

Steel-making pig iron forms 22 per cent. of the production of the Siegerland. It is only a few years since steelworks for the production of mild steel were erected in the district. The first was at Geisweid, then followed those at Bremer, and the Charlottenhütte and the Karl Stein works at Wehbach near Kirchen. Here, too, the proportion of pig iron in the charge does not exceed 25 per cent.

Roll casting forms a speciality of the Siegerland. The collective exhibition of Siegen at Düsseldorf affords brilliant testimony of the extent and high standing of this industry. The chilled iron rolls deserve particular mention. Besides the foundry pig of Siegen, manganese pig iron is used in their manufacture. The foundry pig represents about 13 per cent. of the iron production of the Siegerland. The native spathic ores and Nassau ores are used as well as the rich non-phosphoric Swedish and Spanish ores.

From the same material and also from the Siegen brown ores Bessemer pig is blown. The quantity of this latter represents 5 per cent. of the total iron production of the district.

The Siegen blast-works comprise not only well-arranged large works, but also works with very primitive appliances and small outputs, amounting in many cases to from 40 to 60 tons only, and sometimes not exceeding 12 to 17 tons per furnace and day.

iron is preferably smelted from foreign ores, and has the following composition :—

	Per Cent.
Carbon	3 to 4
Manganese	0·3 to 0·5
Phosphorus	0·2
Silicon	1 to 3

The charcoal is obtained partly by distilling it in retorts at the works, and partly by purchasing kiln charcoal elsewhere.

The works on the Dill and the Laar in Nassau comprise the Buderus Ironworks and the ironworks of Hirzenhain and Lollar. These manufacture from the Nassau hæmatite a foundry pig which contains 0·2–0·8 per cent. of phosphorus. Manganese iron is also smelted from the native ores. Westphalian coke is used, the carriage of which costs about 5s. 7d. per ton for the whole distance of 132 miles from Herne to Wetzlar.

In the paper by Mr. Schlink mention was made of the fact that German iron foundries were with difficulty persuaded to use German pig iron. At the present time this objection is fully overcome, and it is mainly due to the active efforts of the Buderus firm that the prejudice was finally removed.

Group III.—*Silesia and Pomerania.*

The production of iron in this group amounts to 762,843 tons, representing 9·8 per cent. of the whole of the pig iron produced in the country, exceeding the relative proportion of that of Group II. by 1·7 per cent. Of the several varieties manufactured within the group, the proportion to the whole is as follows :—

	Per Cent.
Puddling and spiegeleisen	46
Basic pig	25
Foundry pig	24
Bessemer pig	5

It is noteworthy that in this group the production of puddling iron and spiegeleisen shows an increase over that of 1880. Basic pig began to be blown in 1884, and most of it is manufactured at the Friedenshütte, chiefly for use in those works. The Konigshütte, which has worked the Bessemer acid process since 1872, has now adopted the basic process.

Besides the native ores, tap cinder and pyrites residues are smelted: spathic iron ore from Hungary, clay ironstone of Jurassic age from Poland, magnetite from Schmiedeberg in the Riesengebirge, blackband and Swedish ores, the last-named being imported through Stettin.

In addition to the works mentioned, the following are also situated in Upper Silesia: the Borsigwerk, the Donnersmarckhütte, the Julienhütte, the Falvahütte, the Königs and Laurahütte, the Hubertushütte, the Redenhütte, and the Tarnowitzerhütte.

The daily output of most of the blast-furnaces does not exceed 50 to 70 tons; it is only the newer furnaces at the Königs and Laurahütte, the Friedenshütte, and the Krafftwerk which can produce 95 to 120 tons a day.

Group IV.—*The Kingdom of Saxony.*

This consists solely of a single establishment, namely, the Königin Marien-hütte, at Cainsdorf, near Zwickau. At these works 20,942 tons of pig iron were manufactured, representing 0·3 per cent. of the total production of Germany. Forge iron and open-hearth pig are blown, also Bessemer and foundry pig. The spathic iron ores and brown ores from the Vogtland and Thuringia are used, besides hæmatite from the neighbourhood of Zwickau and Eibenstock in the Erzgebirge, spherosiderite from the Saxon coal district, and cinder.

The Saxon district, in which the works are situated, also supplies the coal for coking. In addition to this, coke from Westphalia and Upper Silesia is also used. The further treatment of the iron is carried on in basic open-hearth furnaces, and the products find a market in the great industrial districts of the kingdom of Saxony and of Thuringia. The blast-furnaces are not at present in operation.

Group V.—*Hanover and Brunswick.*

Two works chiefly constitute this group, namely, the Ilsede Works and the Georg Marienhütte, which together produce 341,985 tons yearly, representing 4·4 per cent. of the iron

Amberg, and the Maximilianshütten are in Rosenberg ı Unterwellenborn. The whole of these works use Westphal coke, for which they pay freight as follows:—

	s.	d.
Bochum to Wasseralfingen	10	11
,, ,, Amberg	11	6
,, ,, Rosenberg	11	5
,, ,, Unterwellenborn	9	7

From the native ores are produced:—

88,000 tons of basic pig.
13,500 ,, ,, puddling and steel iron.
12,000 ,, ,, foundry pig.

It is expressly stated by Mr. Schlink that at Unterwellenb Bessemer pig is the principal product. The authorities of Maximilian works remark in reference to this:—

"Up to the year 1898 Bessemer pig was manufactured at blast-works at Unterwellenborn (Thuringia), the ore used b that occurring in the neighbourhood and also that from spathic iron mines at Kamsdorf owned by the company. 1898, however, the production of Bessemer pig at these wc was suspended, and basic pig has since been smelted f Thuringian ores, obtained from a deposit occurring in Silurian formation near Schmiedefeld. These resemble the smelted by the Prague Iron Company and the Bohemian Min Company near Kladno in Bohemia. On account of their m ganese content the Kamsdorf ores are used as an addition to charge in blowing basic pig. Besides this spiegel and steel i are manufactured."

The Maximilian Works have also secured coal mines in the c district of Hamm in Westphalia. The iron manufactured in t group represents 1·5 per cent. of the total production of Germa

GROUP VII.—*The Saar District, Lorraine and Luxemburg.*

In 1901, 2,896,748 tons were produced within this gro representing 37·2 per cent. of the total production of Germa and exceeding that of the year 1883 in the same district three times. At the same time the quantity of puddling ε steel iron produced is 450,000 tons less, while of foundry 350,000 tons more were blown in 1900 than at that ti

Plate I

New Type of Blast Furnace

with Inclined Hoist on the … System.

been granted free of charge, the idea being to foster the construction of railways in the country without having to make a direct outlay of money. The ore within the railway companies' concession is usually worked on mining leases, and the export of this from the country is permitted. Further, at the place of outcrop the State allowed the ground-owners to have free disposal of an area of 3857 acres. As the land was largely split up into small holdings the result was that in a short time among a large section of the lower classes of the settled population the general prosperity was considerably increased; and besides this, the earnings of the foreign workmen who poured in were spent for the most part in the country."

On the basis of an annual export of 2,200,000 tons, Luxemburg would be able to continue the exportation of minette ore for fifty-six years to come.

If the present rate of consumption of 1,300,000 tons per year is maintained in the blast-works in the country, the supply, according to the present conditions of ownership, would last about 135 years.

The minette district of Lorraine, with concessions of a total area of about 102,300 acres, has eleven times the extent of that of Luxemburg, and apart from a few unimportant pockets the whole of this is already taken up. At the end of 1896 the ownership was distributed in the following proportion: 55,850 acres were appropriated by the works in the minette district and those bordering on it (Rote Erde, Metz and Co., Angleur, Rodange, Villerupt, Düdelingen, Roechling, Dillinger Hütte, Burbach, Boecking & Co., De Wendel, Stumm, Rombach, Novéant, Lamarche, Quint).

The Rhenish Westphalian works own 7060 hectares (Gutehoffnungshütte, Phœnix, Krupp, Rheinische Stahlwerke, Siegrheinische Gewerkschaft, Bochumer Verein, and Spaeter). The remaining 28,670 acres are owned privately.

The principal centre of the mining industry in Lorraine is at present situated in a district which begins a few miles south of the Orne, and extends in a northerly direction towards the Luxemburg frontier.

The importance of Lorraine for the German iron industry consists chiefly in the great extent of ores containing lime.

Regarding the composition of the varieties of iron and the procuring of manganese ores Mr. Kloeckner remarks :—

"Neither in Luxemburg, Lorraine, nor on the Saar is any steel iron or other iron of special quality manufactured, such as hæmatite. In the western district are produced only (1) Basic pig with 1·5 to 1·6 per cent. of manganese, containing about 2 per cent. phosphorus, 0·12 per cent. maximum sulphur, about 0·5 to 1 per cent. silicon; (2) Basic pig with less than 1 per cent. or without addition of any manganese, and containing 2 per cent. phosphorus, 0·12 to 0·15 per cent. sulphur, and about 7 to 7·2 per cent. silicon; (3) Puddling pig, with about 0·5 per cent. of manganese, about 2 per cent. phosphorus, 0·2 to 0·4 per cent. sulphur, and 0·8 to 1·5 per cent. silicon; (4) Foundry pig, containing—

	Si.	P.	Mn.	S.
No. III.	2·4	1·8	0·5	0·05
No. IV.	2·2	1·8	0·5	0·05
No. V.	1·8-2	1·8	0·5	0·05

The manganese used in the manufacture of basic pig is chiefly imported in the form of manganese ore by way of Antwerp. The ores are mostly from Poti, Greece, and from India, but in addition to them Nassau ore and manganese ore from the Hunsrück are smelted.

The quantity of foundry pig produced within Group VII. is very considerable, being somewhat less than one-third of the production in Germany of this variety. The composition of the iron resembles that of the Middlesbrough pig iron, and it is used in most of the German foundries. The ease with which it can be melted, owing to the high phosphorus content, renders it extremely suitable for pipe founding and for hollow goods.

The conditions governing the production of iron on the Saar are different from those of Luxemburg and Lorraine. The blast-works there depend on the railways for their supply of minette, only a very small portion being conveyed by the Saar canal. This waterway is of more importance in the transport of slag from France.

in rapid succession of a number of new works in the minette district and on the Rhine, as well as the rebuilding of older plants, afforded the opportunity to profit progressively by the experience accumulated during the time of unprecedented increase in the production. The greater portion of all the installations were constructed in accordance with the designs or advice of the eminent engineer, Mr. F. W. Lürmann, the inventor of the slag tuyere. But before discussing the blast-furnace plants in detail, the progress in the manufacture of coke calls for some attention.

The iron manufacturers require that the ash content of good coke should be as low as possible, and that the resistance to crumbling should be as high as possible. By the introduction of coal-washing plants, coke can be produced with a very low ash content. The loss of coal in the process of washing was, however, very considerable, and since the carrying capacity is a more important consideration than the ash content, the latter was allowed to remain at 8 to 9 per cent.

To obtain a firmer coke, the coke-makers add to the regular coking coal a proportion of splint coal. Special mixers are used, which permit of regulating exactly the amount added and ensure uniformity in the mixture.

A greater degree of density is also imparted to the coke by the stamping of the coking coal. This is effected in boxes which are traversed in front of the ovens. This process is extensively used in Upper Silesia, but it appears likely to be adopted in Westphalia on a larger scale than formerly.

The most important agent in the production of hard coke is a highly heated oven. In the Coppée oven, which is almost universally used in Germany, the hot working is attained by making the chambers narrow and not too high.

An improvement of considerable importance for ovens with by-product recovery plant was effected by the Otto method of bottom-firing. These ovens have a coking time of twenty-two to thirty-six hours, according to the kind of coal used and the internal width of the ovens. By the heat of distillation of 1 lb. of coal charged 1·2 lbs. of water are evaporated, a result which is rarely exceeded in ordinary ovens.

According to Dr. H. Wiechel, the production of coke in by-product ovens in Germany, for 1900, was 42 per cent. of

removal of the crushed slag. At the Henrichshütte at Hattingen the whole of the raw material is carried to the blast-furnace by means of these suspended tracks.

Where it is not the practice to grind the slag, it is got rid of by pouring it into tubs on tipping waggons of about ten tons capacity; or it may be removed in ladle waggons similar to those for liquid metal. The waggons are very often of standard wheel gauge. A number of these have been built by the Junkerather Company.

Owing to the certainty with which the phosphorus, the heat-agent in the basic process, can be introduced into the pig iron, the practice of conveying the iron in the liquid state from the blast-furnace to the steelworks has been everywhere adopted where the local conditions were favourable. Mixers with tilting arrangements, which contain up to 250 tons of metal, are also installed at almost all these works. Among many other advantages attending the transport of liquid metal not the least is the great economy in labour gained thereby. Under these altered conditions the term "pig iron," familiar also among German iron-workers, certainly appears to lose its significance. Casting-machines have not been adopted in Germany, for the reason that almost all the iron is sold according to analysis, or is at least carefully sorted.

In recent years the exterior of the blast-furnace has undergone considerable modification (Plate I.). The heavy cast-iron columns supporting the cast-iron bearer plate are now seldom used, nor is the framework, consisting mainly of four corner columns carrying the top charging platform. In the newer installations eight columns are arranged round the furnace-body, which stand upon the foundation below the free-standing hearth. These are carried up to the charging platform, and the wrought-iron bearer plate is supported on brackets projecting from them, also the platform giving access to the tap-hole and the tuyeres. The casing of the hearth and boshes is constructed of strong rivetted plates, though it often occurs that the boshes are constructed with cooling rings and wrought-iron hoops. The furnace-body is held together by strong hoops. The expansion of the furnace-body is provided for by means of stuffing boxes beneath the charging platform. At some works the furnaces are built of bricks of small dimensions, laid with cement. Carbon bricks are also much used. Mr. Burgers of Schalke has constructed a furnace at the Vulcan

an iron grid, and also on stonework. Instead of the valves as constructed by Cowper, the revolving valves of Schmidt are sometimes used. For closing the cleansing openings, the Morton doors are much in favour.

The blast-furnace industry has taken full advantage of the great progress in steam-engine construction in Germany. It also became clear that the large surplus of gas obtained in the working of several furnaces might be usefully employed in generating electricity which could be distributed as power to any desired part. Not only the large works combined with dependent installations, but also smaller works began to put down central electric power stations, and the collective output of power, amounting to 1200 horse-power, permitted the employment of compound engines.

This was followed by the construction of blowing engines on this principle, the horizontal type being in general preferred for the blast. The increased piston-speed as compared with the older steam engines was productive of some difficulty with the direct-driven blowing engine, as it was found that the leather valves in common use could no longer be depended on. Added to this was the necessity to increase the blast-pressure. By the introduction of lifting valves instead of flap valves this defect was obviated. Two systems of valves are chiefly used, namely, the Riedler-Stumpf and the Ganz-Hörbiger. These are on view at the exhibit of Oechelhäuser and Kleins.

The adoption of the compound steam engine necessitated the raising of the boiler pressure. At the present time a pressure of 120 to 150 lbs. per square inch is usual. The Cornish boiler is most in favour, but the improved method of cleansing the gas now permits the use of more complicated types, among which are water-tube boilers with mechanical scrapers. Boilers with special firing arrangements are principally used.

In spite of the notable improvements effected in the steam engine in recent years, these will with difficulty hold their own against the engines driven by blast-furnace gas. How rapidly the latter are coming into use is shown in a striking manner on comparing the Paris Exhibition with that of Düsseldorf. At Paris the 600 horse-power blowing engine of the Delamare-Deboutteville type built at Seraing attracted the attention of technical men of all nations as the largest and sole existing

other furnaces was 1661 tons, or 415 tons per furnace. The extraction from the ore mixed with flux charged was 42 per cent.

The employment of labour at the blast-furnaces varies exceedingly, so that comparative data are scarcely obtainable. To add to the difficulty, the particulars submitted by the works frequently include the industries connected with iron-making, such as coke-making, brick factories, &c. Again, those works which manufacture every kind of iron naturally have to stock ores of all kinds on a large scale, which increases the cost of transport of raw material. Finally, those blast-works which treat the pig iron in the liquid state can economise considerably in labour.

Still, the figures for some of the works may be of interest:—

	Production.	Number of Workmen.	Output per man per year.
	Tons.		Tons.
Deutscher Kaiser Company .	208,651*	980	419
Hörder Verein . . .	255,720	685	373

The following data were also given by the kindness of the Hörder Verein:—

Blast-Furnace Works at Hörde.

Year.	Production of Iron.	No. of Workmen Employed at the Blast-Furnaces.
	Tons.	
1880–81	77,276	602
1881–82	82,204	595
1882–83	90,481	583
1883–84	94,078	659
1884–85	99,442	558
1885–86	106,468	549
1886–87	91,256	574
1887–88	131,633	513
1888–89	121,898	470
1889–90	134,785	478
1890–91	122,618	474
1891–92	147,500	497
1892–93	146,570	491
1893–94	178,762	517
1894–95	181,241	565
1895–96	215,835	583
1896–97	218,640	581
1897–98	239,990	694
1898–99	250,956	645
1899-1900	274,099	772
1900–01	279,444	800
1901–02	255,720	685

* January 1 to June 30, 1902.

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PROGRESS IN STEELWORKS PRACTICE IN GERMANY SINCE 1880.

By R. M. DAELEN (Düsseldorf).

Since the last occasion on which the Iron and Steel Institute visited Germany in the year 1880, a notable development has taken place in the production of steel in this country, and to-day again, as formerly, the Industrial Exhibition of the Rhine provinces and Westphalia affords a fitting opportunity for taking note of the progress which has been achieved in recent years. The author therefore proposes in the present paper to give, in as brief a space as possible, an account of the recent progress and of improvements of a more important character which have been effected in the domain of steel manufacture on a large scale. The commencement of this period dates from the introduction nearly fifty years ago of the invention of Henry Bessemer, and a subsequent impulse was given by the later development of the Siemens-Martin open-hearth furnaces. But in 1880 the annual production of wrought iron in Germany still amounted to 1,270,000 tons, while that of mild steel was not more than 625,000 tons. In the year 1901 the former figure had, however, fallen to 900,000 tons, and the production of mild steel for that year rose to over 6,000,000 tons, the classification being as follows:—

	Acid Process.	Basic Process.	Total Mild Steel.
I. Ingot metal	Tons.	Tons.	Tons.
(a) produced in the converter .	299,816	3,975,070	4,274,886
(b) produced in the open-hearth .	125,590	1,886,536	2,012,126
II. Steel castings	39,634	67,576	107,210
Total production . .	465,040	5,929,182	6,394,222

The above represents the output of 103 steelworks in 1901.

long time to come, on account of the nature and qua the ores available. The somewhat stringent requireme the consumers as regards the quality of the finished pr are also best met by this method of production. A diffi is now, however, beginning to be felt in some district obtaining pig iron with the necessary percentage of phosph which should amount to about 2 per cent., and in consequ the numerous efforts to discover a process in which a lo percentage would suffice appear to be fully justified. Sev works have already found themselves compelled to retur portion of the converter slag to the blast-furnace in order obtain the required quality of basic pig, and the phosphorus thus kept in circulation. Since, with the above proport which cannot often be exceeded, no considerable evolution heat occurs in the converter, the remelting of waste pieces possible in a very much less degree than is the case in a working. Consequently a greater number of open-hearth furnac is necessary for dealing with the waste and scrap. These a generally of the basic system, lined with crushed dolomite, an their capacity is about 15 to 20 tons. A capacity of 30 tons rarely exceeded, and there are in existence only very few furnace of 50 tons.

In the west of Germany the usual practice is to melt a charge consisting of 25 per cent. pig iron and 75 per cent. small scrap, six heats per twenty-four hours being obtained from a 15-ton furnace, while from a 25-ton furnace not much more than four are possible in the same time. From this it would appear that, since the output remains about the same, no particular advantage is gained by the adoption of larger furnaces, unless it is a question of producing very large and heavy ingots or castings. The initial outlay in constructing a large number of small furnaces is not so great as that required for the construction of a smaller number of large furnaces, and the consumption of fuel, amounting in the former case to 270 kilogrammes per ton of steel, is not in any way reduced by using larger furnaces. On the other hand, the number of charges per day falls to 2½ when the proportion of pig iron is increased to 80 per cent., a practice often followed in the east of Germany, and in that region, therefore, furnaces of larger capacity can be more suitably employed.

ative, although in consequence of the attitude of the syndicates the raw material is relatively more expensive than the half or completely finished products of the rolling-mills. In other respects the determined endeavour of German technical industry to discover new markets for iron products is manifested by the buildings of colossal proportions at the Düsseldorf Exhibition and their contents. A comparison of them with the buildings at the Exhibition of 1880, or even with those of the Paris Exhibitions of 1889 and 1900, shows that structures of iron pure and simple have to some extent given way to a combination of ironwork with stone and concrete. This is, however, by no means to be regarded as a retrograde step in the application of iron to such purposes, but is indicative of the endeavour to solve the important problem of finding adequate means of protecting the ironwork of buildings from becoming heated by an outbreak of fire within. Iron alone does not confer safety against the effects of fire. The necessary steps towards the achievement of this have already been initiated, and the thirty years of successful endeavour in extending the use of iron on the part of German technical science are a sufficient guarantee that a satisfactory solution of the question will be found. The compiling of the book of standard sections and the publication of standard designs for iron structural work furnish an eloquent proof of the ability to deal successfully with the matter.

The above is a brief review of the general situation of the German iron industry. Returning now to the methods in use for the further treatment of steel, it will be found that the older-established works have for the most part retained the well-known system of casting ingots, consisting of a hot-metal ladle carried either on a slewing or travelling crane, and successively placed above the stationary ingot-moulds. On the other hand, only a few of the more modern works have adopted the reverse method of drawing the ingot-moulds along beneath a stationary ladle, combined with which process is also the forcing out of the ingots from their moulds by mechanical means.

The latter method does not permit of filling several moulds at once by bottom pouring, and its adoption has extended according to the ability to roll rough ingots at one heat into finished products such as wire, rods, small sections and plates, which

latter medium is particularly suitable for welding, though in other respects water-gas has not yet found extensive application in ironworks, since the Siemens producer-gas, containing 40 per cent. or more of available fuel, still meets all requirements.

In the manufacture of seamless tubes and hollow bodies, two methods are principally employed:—

1. That of Mannesmann, which consists in producing a hollow in the interior of a cylinder by expanding the surface.
2. That of piercing a solid billet with a mandril.

In both cases the tube is finished by rolling out or drawing over a mandril. The latter process has been greatly developed by H. Ehrhardt, of Düsseldorf, who manufactures seamless boiler rings besides tubes and projectiles. His products are to be seen in the exhibit of the Rheinische Metallwaaren und Maschinenfabrik.

To keep pace with the production of the steelworks, the daily capacity of the machines and appliances for working up the material, and of the rolling-mills in especial, has been increased. Wherever possible, every appliance which is the outcome of the ceaseless progress of modern invention has been brought into play to lower the cost of production. To enter fully into the whole of such details would occupy too much time, and the author therefore limits himself to the following points: The introduction of the blooming-mill for small and large ingots, and the development of the two-high and three-high trains as finishing-mills, with continued improvement in the methods of counterbalancing; and the use of valve-gears of precision for controlling the rolling-mill engines when working at the highest speed of piston and maximum revolutions per minute. After many trials with valves and slides, the form of valve which has found most favour is the cylindrical with a motion in the direction of the axis, the Corliss valve also, in some cases, having been adopted. Very considerable economies have also been effected by the use of efficient condensers, particularly of central installations of these, and recently by the employment of superheated steam. Quite recently it has been attempted, experimentally, to drive rolling-mills direct by means of gas

the method of driving without a flywheel would certainly be best suited. The same rule would hold good so long as the rolls exceed 600 millimetres (2 feet) diameter, and so long as the two-high system does not involve a considerable increase in the number of stands. The extra cost of these would, however, be compensated for in great part by dispensing with the lifting tables, and by the consequent simplifying of the live-roller driving gear, and of the upsetting gear. Less hand labour would also be required.

With regard to the Grey universal mill at the Differdingen Works, Mr. Meier, the managing director, reports that it has now been satisfactorily proved that by this method of rolling the object in view can be fully attained, namely, that of rolling girders with flanges of quite abnormal width, in order to save rivetting in columns, runway girders, &c. The girders can also be rolled with a greater depth than has hitherto been possible. Definite figures as to the cost of manufacture are not yet available, since the production is at present too small to enable a fair estimate to be made, and sufficient time has not elapsed to allow for the creation of a regular demand for the new sections. But it can already be stated with certainty that this mill turns out the special sections at any rate almost as cheaply as standard sections can be produced on an ordinary mill. Thus the chief apprehensions as to the rapid wear of the rolls have not been justified, but on the contrary the wear per ton of material rolled is found to be no greater than in an ordinary mill, for the reason that the weight of the rolls for the large sections is considerably less than in the ordinary mill.

With regard to the number of rolls to be provided for a rod and bar-iron mill, it may be mentioned that as the result of improvements in the balancing a considerable reduction in the length and number of rolls has already been effected, and there is a prospect of a further advance in this direction. In practice the two-high mill gives a greater daily output, and suffers less from abrasion than a three-high mill, owing to the greater speed of the rolls in the latter, and because the middle roll has twice the work of the other two, being used at every pass. The changing of the rolls is also easier with a two-high than with a three-high mill. In this connection it is advisable, when

of their market—these are of so diverse a nature, and orders for one quality or form of product are by no means of the same magnitude here as is often the case in the same industry in other countries. In arranging the buildings and machinery, the chief aim to keep in view is accordingly not only a large daily output and the saving of labour, but it consists rather in devising how to do work at remunerative rates even with apparatus and machines of medium productive capacity, and with frequent changes in the kind of material supplied. If on this account the German works are less imposing as compared with modern installations abroad, we can console ourselves with the reflection that circumstances must be adapted to meet conditions, and that limits can be set to all competition, however much this may be feared.

be about the limit of physical endurance in the labour of charging, so that unless the increased size of furnace was arranged to be charged mechanically, with charging machines such as were adopted in nearly all the open-hearth plants in America, full advantage of the larger furnace would not ensue. With mechanical chargers and 50-ton furnaces using 50 per cent. scrap, an output of about 900 tons per week was attained in American practice. With reference to the relative time of cooling of acid steel ingots as compared with basic steel ingots, he might say his experience had been that basic steel ingots took longer to cool than acid steel, because the basic steel was generally of a more lively nature, and, speaking in a general sense, the more lively the steel, either acid or basic, the longer it took to set. The contraction of the ingot however would, he thought, be *pari passu* with the radiation of the heat, and when the ingot was sufficiently set to permit of drawing the mould, the heat of the ingot in both instances would be somewhat similar.

CORRESPONDENCE.

Mr. A. Greiner, Member of Council, stated that Mr. Max Meier had ordered for his works at Differdingen a 1200 H.P. blast-furnace gas engine for driving a merchant mill, and it was contemplated within a few days to order another one of 2000 H.P. for a wire-rolling mill. An engine of 1200 H.P. was about to be ordered for Mr. Trasenster of the Ougrée Steel Works, for a merchant mill. The gas would be brought from the blast-furnaces to the mill, a distance of 400 to 500 yards, through 18-inch iron piping. The pipe would be led over the village street, but as the permission of the authorities had still to be obtained for its passage, the order for the engine had been postponed for a few weeks.

Mr. Daelen wrote in reply to Sir James Kitson that the application of electricity to the driving of rolling mills would in future gain ground wherever it was found to be more economical than steam driving, since experience with the present installa-

The rheostat for the main or compound coils was on the other hand placed in series to these, so that the current which flowed through them was weaker in proportion as the resistance of the rheostat was lessened. With the aid of the shunt rheostat the motor was speeded to run at between 330 and 450 revolutions per minute, the more accurate adjustment of the speed being effected by means of the main rheostat. In addition to the above two resistances a third was provided in the controller. This was used for starting and stopping, and was short-circuited as soon as the motor had attained the normal speed. Upon the controller from which the shunt coil branches was also fixed a magnetic spark preventer. A direct current motor was chosen because it had the advantage over the polyphase system that a battery could be interposed between the motor and the generating station, which served as a protection to the latter against shocks. At the same time the battery acted as a reserve in case of a stoppage in the central power station. Other advantages relating to ease of control have already been dealt with. If the motor house were suitably isolated from the rolling mill shed the motor would be protected from dust and would be as reliable in its working as a polyphase motor. The mill served to roll mild steel and wrought iron into rounds and flats of $\frac{3}{16}$ to over $\frac{3}{4}$ inch diameter or width, also flat bars $\frac{3}{4}$ to $1\frac{1}{4}$ inch wide, and hoop iron of $\frac{5}{8}$ to 1 inch wide and $\frac{1}{16}$ inch thick and upwards. It consisted of a set of roughing rolls, the length of roll being 3 feet 10 inches, and the diameter $12\frac{5}{8}$ inches, and of the finishing mill with seven stands, the length of roll being 2 feet and the diameter 9 inches. Electric driving had proved in every way satisfactory, and no stoppage had ever occurred since the mill was put into operation in May 1901."

With regard to the relative merits of electricity or hydraulic pressure for driving cranes, his (Mr. Daelen's) view was that the former was chiefly advantageous on account of offering an easier means of transmitting power and of regulating the supply of power. But the conversion of the high velocity of a rotating electric motor into the comparatively slow straight-line motions of cranes rendered necessary the introduction of a large number of mechanical parts, such as spur-gearing, and these were exposed to the risk of breaking down or of rapid wear and tear. This

increased cost of plant. Charging-machines were installed in the majority of works, the advantages of which, as was well known, consisted chiefly in the saving of manual labour, while the yield of the furnace was not inconsiderably increased. Several types of charging-machines were in use, among which those constructed in accordance with the author's own design, as illustrated in *Stahl und Eisen*,* were especially deserving of notice. These were constructed to travel upon overhead runways, and a platform of great strength was not required. They could therefore be adapted to most of the existing steelworks.

With reference to driving rolling mills by electricity, the Allgemeine Elektricitäts Gesellschaft of Berlin reports as follows upon the motors supplied by them for this purpose: "Two motors have been installed in our cableworks since the beginning of 1898 for the purpose of driving the rolling mills, a description of which plant appeared in *Stahl und Eisen*.† The roughing rolls are driven by a motor of 200 horse-power working at 380 revolutions per minute, the motion being transmitted by ropes. A second motor of 400 horse-power is coupled direct to the finishing rolls and makes 420 revolutions per minute (similar to the arrangement at Peine). Besides these there have been constructed two motors, each of 100 horse-power with 500 revolutions per minute, for the works of William Prym in Stolberg; two motors of 285 horse-power and 350 horse-power respectively, running at 375 revolutions, for the tube rolling works of the Deutscher Kaiser Company at Dinslaken; one motor of 300 horse-power and 187 revolutions for the Domnarfvets Iron Company in Sweden; and one motor of 450 horse-power with 187 revolutions for the Langscheder rolling mills at Langschede in Westphalia. All the above are polyphase motors and have never caused trouble at any time since starting, and they may therefore be regarded as suited to the exigencies of rolling mill work. We have never up to the present supplied any motors for reversing mills. When a plant of large power is concerned, special regard must be paid in each case as to whether the power station can withstand the shock caused by the exceptionally sudden application of the load. The effect of this

* Vol. xxii., 1902, No. 15, Plates XVI. and XVII.
† Vol. xx., No. 19.

IRON AND STEEL AT THE DÜSSELDORF EXHIBITION, 1902.

By Professor HERMANN WEDDING, Ph.D. (Berlin), Honorary Member of the Iron and Steel Institute.

The Exhibition at Düsseldorf is limited both objectively and territorially. It does not aspire to be a world's Exhibition, nor does it even represent the whole of German territory, but is confined solely to the Prussian provinces of the Rhine and Westphalia.

Of the important iron manufacturing districts, those of the provinces of Silesia and Hanover, and that of the imperial province, Lorraine, which contain besides the most celebrated iron ore deposits of Germany, are not included, the only iron-mining district of note represented being that of Siegerland. On the other hand, the most extensive coal-mining regions, apart from that of Silesia, that is, the Ruhr and Rhine, the Saar and Aix-la-Chapelle districts, fall within the scope of the Exhibition.

The metallurgy of iron and machine construction in all its branches are so overwhelmingly represented, that in comparison all other objects and the industries connected therewith appear to fall into the background. The members will however find that this limitation is no defect, but, on the contrary, constitutes a decided advantage. For metallurgists this Exhibition offers a display which, in point of completeness and imposing magnitude, has hitherto been unexcelled.

It is now the author's task, undertaken at the request of the Council of the Institute, to conduct the members through the iron-metallurgical section of the Exhibition, if they will consent to entrust themselves to his personal guidance.

The division between the section devoted to the metallurgy of iron (Group II.) and the other parts of the Exhibition is not sharply defined, since there are numerous appendages and side exhibits

(148 feet). The core lying near exhibits the excellent compactness of the material, as also does a glance through the hollow of the shaft while illuminated. The ingot from which the shaft was forged was formed from the contents of 1768 crucibles, and was completed in thirty minutes, 490 workmen being required for the work of casting. Crucible steel ingots are cast at Essen up to 85 tons, and ingots of open-hearth steel are made up to 120 tons.

Shafts made of a 3·6 per cent. nickel alloy of iron are forged under hydraulic presses, the largest of which is of 5000 tons pressure. Especially noteworthy are the enormous castings of mild steel, among them the stems and sternposts for warships and the mercantile marine.

It is almost superfluous to enlarge upon the great armoured turrets with electric machinery for revolving them, for serving the large guns and handling projectiles. These will be exhibited in actual motion. Every one is more or less acquainted with the renowned products of the Krupp works in respect of war material. Among these must also be reckoned the armoured domes of chilled cast iron, which among other excellent productions are exhibited by the Krupp Gruson works in the apse of the building.

The next building which is entered contains the objects placed on exhibition by the Hoerder-Bergwerks und Hütten-verein (No. 503). What attracts the attention here is chiefly shipbuilding and railway material. Ship plates, reverse-bars for the ship-framing, deck-beams, &c., of excellent finish are shown. A marine boiler end-plate of 3·6 metres (11¾ feet) in diameter is formed of a single piece of plate, the material being open-hearth steel. A marine crank-shaft of 550 millimetres (22 inches) diameter, also of open-hearth steel, is displayed. All the shafts are bored out through the centre, partly with the object of reducing their weight and partly to obtain assurance as to the soundness of the material within. The perfection of the steel castings is particularly evidenced in the appearance of the huge sternposts with rudder and propeller. It will be noted that the surface of the machined parts of wheels, shafts, &c., are almost entirely free from blow-holes.

The Hoerde works have in recent years taken a leading part

barrels for double and treble-barrelled guns, and even large gun tubes are manufactured by this process. The initial operation in the manufacture of boiler ring courses is performed in a similar manner, the hollow billets being afterwards rolled out into cylindrical rings on a rolling-mill. Thus both riveted and welded seams are dispensed with in the finished course.

Crossing the main avenue of the Exhibition the pavilion of the Gutehoffnungshütte of Oberhausen is reached (No. 501). In front is presented to view a large winding-engine. On turning to the right the spectator is confronted with an extensive collection of ores, pig irons, and other material. The variety of the kinds of iron produced at these works is shown by the large number of rolled sections, and massive plates afford evidence of the capacity of the rolling-mill. Forgings and castings of excellent quality, representing orders for the most part, are a proof of the remarkable progress which has been achieved in Germany with regard to the soundness of the castings and cleanness of execution manifest even on the rough exterior.

In making the tour of the building, numerous interesting illustrations of the development of the works from small beginnings are presented. Samples of wheel-bosses and pulleys, tires, and bridge-building material are on view, which exhibit a remarkable degree of toughness.

The whole attention is now centred on the large blowing engines, at present driven with producer gas, but later to be worked by blast-furnace gas. The peculiar arrangement of having the blowing cylinders placed at the side is due to the desire for economy of space lengthwise. The engine is of the two-throw type. The firm has contributed largely to the rapid development of gas-engines driven direct by blast-furnace gas, and is experienced in all systems of such motors. Some idea of the serviceableness of their machines may be gained from this fact.

Four smaller pavilions are now entered, the first one being that showing the Goldschmidt process (the Thermite Company), No. 499, where may be witnessed the welding of portions of iron by means of thermite, a mixture of aluminium and oxide of iron; also the reduction of carbon-free metals, more particularly manganese and chromium. Next is the Niederrheinische Hütte,

hand. On the left again, follows the Duisburger Eisen- und Stahlwerk (No. 488), showing specimens of heavy work, in particular end-plates for marine boilers.

The exhibit of the German-Austrian Mannesmann tube-works (No. 486) is the next in turn on the right. This most instructive collection displays the process of tube manufacture by the method of oblique rolling, which failed to fulfil all that had at first been expected of it, and is now only used in the preliminary stage of manufacture. The tubes are brought to their final state of perfection by the use of the so-called Pilger process.

Confronting this is the stand of the Krieger Steelworks (No. 525), with beautiful specimens of the firm's products, comprising for the most part shipbuilding material.

The collective exhibition of the Siegerland is now entered (Nos. 387 to 478). This district forms the southern part of Westphalia, and is widely celebrated on account of the great wealth of its mineral lodes, containing spathic iron ore, rich in manganese, from which are produced white pig iron and spiegeleisen. The progress achieved here in the last decades may be noted by comparing the two full-sized models of an old and a new blast-furnace. Mention must also be made of the models of Burgers, of Schalke, not alluded to in the catalogue, which show how a blast-furnace may be constructed entirely of iron, provided it is properly cooled on the outside.

On arriving at the end of the central passage and turning to the left an extensive exhibit is seen, consisting of chilled rolls of great superiority. These form a speciality of the Siegerland. Unfortunately, no fractures are shown of these rolls, which are manufactured in different degrees of hardness; by this means the depth to which the hardening penetrates would have been apparent.

The way now leads past several small exhibits, Söding and Halbach (No. 524), the Aplerbeckerhütte (No. 380), and Capito and Klein (No. 485). The latter shows some thin plates made of Siegerland iron. These are followed by the Aachener Hütten Aktien Verein at Rothe Erde (No. 379), and again the Phœnix works. Then taking a passage turning off to the right the tube and plate-making section is once more passed through. Boecker & Co. of Schalke (No. 432) and the stand of the Wittener Guss-

On looking back towards the entrance, the exhibit may be observed of the Rheinische Stahlwerke (No. 517), which affords many proofs of the improvements in mild steel castings as well as in forgings and rolled pieces. The Hochfelder Walzwerke are also represented, showing chain cables for ships. Besides this there is the Emscherhütte exhibit (No. 381).

Adjoining Group II. is the comparatively small Mining Section, Group I. This can be entered direct from the former; and thence the extensive sub-section of the Association for Mining Interests of the Dortmund district is reached, forming part of the same group. Here, contrary to the general rule, are represented not only the productions of the Rhineland and Westphalia, but also those of other mining districts of Germany.

The Machinery Hall is then reached, where gas-engines, blowing-engines and rolling-mill engines are at work, of which the thorough study would occupy many days. These are objects, however, which do not enter within the scope of the present paper, and the author will therefore take leave of the members at this point, in the hope that they may find a guide better qualified than himself to conduct them through this department.

On the motion of the PRESIDENT a cordial vote of thanks was accorded by the members to the author for his interesting and instructive paper.

The following paper was then read :—

0·1 per cent. of carbon. There is, moreover, a distinction to be drawn between overheating and burning. The term "to burn" conveys the idea of a process of combustion, that is, a taking up of oxygen by the metal, implying that a chemical change has taken place. The author accordingly defines "burning" as a chemical change in metals, especially with respect to the taking up of oxygen by them; this change, of course, affecting their physical properties. "Overheating," on the other hand, he considers to mean an increase in the brittleness of metals brought about by heating under special conditions, but involving no change in the chemical composition; that is to say, it is a purely physical process. The difference between overheating and burning is most noticeable in the case of copper. By exposing copper for a length of time to a high temperature which does not exceed T–20°, T being the point of solidification of pure copper, the bending capacity of the copper is greatly reduced; it becomes, in fact, overheated. Apart from the formation of a film of copper oxide on the surface, however, no chemical change is discernible. If, on the other hand, the temperature T–20° is reached and maintained for a time, the copper takes up oxygen from the air forming oxide of copper, and thus undergoes a chemical change. It is then burnt. The formation of copper oxide is not confined to the surface, but takes place equally throughout the whole mass. The resulting material is not copper, but an alloy of copper and oxide of copper, as is shown in the photograph (No. 1, Plate II.), at a magnification of 365. The small globules dotted over the surface, which appear grey in the photograph, are the oxide of copper.*

The following paper deals only with the overheating of mild steel, that is, with a change of purely physical character unaccompanied by a chemical change. That the changes produced in the properties of such steel by overheating can have a most disastrous effect in practice does not require to be specially emphasised. Mr. Stead, in his paper above alluded to, has furnished various examples of this, and the author

* Further information on this subject will be found in the communications to the Royal Technical Testing Institution, Charlottenburg, for 1900, p. 315, under the title of "Copper and Oxygen," by E. Heyn; and also in a paper by the same author, "Short Communications from the Metallurgical-Metallographical Laboratory of the Royal Technical Testing Institution, Charlottenburg," presented at Budapest Congress of the International Association for Testing Materials.

one another. On the other hand the inner or core zone, of a thickness of about 11 mm, differed considerably from the

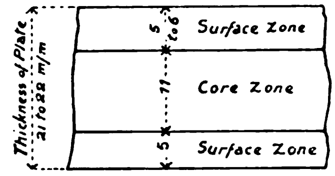


Fig I.

former. Hence arose the necessity of taking the test pieces for each of the tests enumerated above from the surface zones and the core zones separately. This, again, introduced another condition, that all the test pieces must be less than 5 mm. in thickness. The tests *a* to *c* and the values obtained by them are co-ordinated in Table I. below. It will be observed, on studying these tabulated results, that these tests afford no indication of the degree of brittleness, since the values obtained are in general sufficiently satisfactory to ensure the acceptance of the material, notwithstanding the unmistakable extreme brittleness. The results of test *c* are somewhat more useful, but nevertheless the figures obtained are not of a nature to serve as a guide in judging the brittleness of the plate.

TABLE I.

State of Material.	Zone from which Test Pieces were taken.	*a.* Tensile Test.				*b.* Bending Test with Plain Bar under Dead Load.		*c.* Bending Test with Notched Bar under Dead Load.	
		Limit of Elasticity.	Yield Limit.	Elongation at Point of Rupture.	Ratio of Elastic Limit to Yield Limit.	Angle of Bend.	Bending Quantity.	Angle of Bend.	Bending Quantity.
		Kg. per Sq. Mm.	Kg. per Sq. Mm.	Per Cent.	Per Cent.	Degrees.	$\frac{50a}{r}$ *	Degrees.	$\frac{50a}{r}$ *
As delivered to the laboratory	Surface zone	23·1	33·5	22·1	69	180	100	90	23
	Core zone	19·5	32·6	23·1	60	180	100	144	38
Annealed at 750° C.	Surface zone	13·9	29·3	29·9	48	180	100	180	56
	Core zone	17·1	31·7	27·1	54	180	100	174	51

* a = thickness of bending specimen ; r = radius of bend.

and the depth of notch was fixed in such a manner that the bars from the most brittle portions of the plate—that is to say, the material in which brittleness was known to exist—were fractured at once under the first blow of the hammer, while other less brittle bars were bent by an equal force to an angle of 90°, and after straightening withstood bending a second time with the hammer. In Fig. 2 are given the measurements of the test bars and the notch.

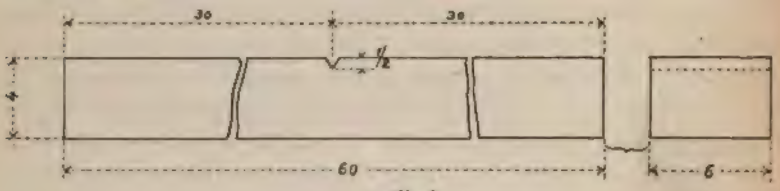
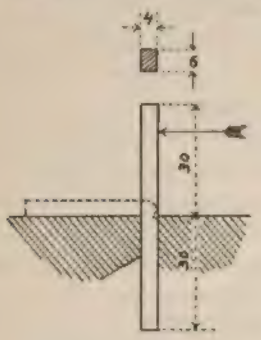


Fig 2.
Dimensions in Millimetres.

It will be observed that the notch was V-shaped, and had a depth of 0·5 millimetres. It was cut on a planing machine, on one side of the bar only, with a tool of special form. The manner in which the impact bending test was made is rendered clear in Figs. 3 and 4. The bar (see Fig. 3) was gripped in a vice, and a short heavy blow with the hammer was then struck at the point indicated by the arrow on the notched side.



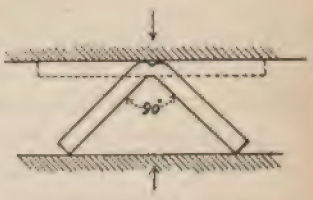


Fig 4.

Fig 3.

If the bar was not broken, the blows were repeated until it assumed the position shown by the dotted line, that is, bent to an angle of 90°. It was then released and straightened by

since considerable differences are to be noted in the behaviour of the zones, especially after annealing, and in those specimens from the less brittle parts. Added to this circumstance is the fact that within the same zone the brittleness varies in different parts of the plate. It did not therefore seem expedient to carry out experiments with the material of the plate for the purpose of producing brittleness artificially by means of heat treatment, especially as it was not possible to judge whether the results would not be influenced by the original state of the plate. A more correct procedure would evidently be to begin experiments upon material as nearly homogeneous as possible, whose initial brittleness was as low as possible, and the history of which was known. In the light of the experience thus gained, the trials could afterwards be extended to the brittle boiler plate.

In accordance with this reasoning, a rolled bar of 26 × 26 millimetres of basic open-hearth steel was selected for the experiments, the material being very homogeneous. Only in a limited area in the centre of the section were observable slight traces of a core zone. For the sake of convenience in the following pages the term S 660 is used to denote the material of this bar. For the tests about to be described no test specimens were taken from the core zone, but only from the thick surface zone, and these, representing the condition of finished steel, after repeated trials gave $3\frac{1}{2}$ as the bending number. The chemical composition of the bar S 660 is given below, and for purposes of comparison, the analysis of the boiler plate is also added.

	Mild Steel Material S 660. Surface and Core Zones.	Boiler Plate.	
		Surface Zone.	Core Zone.
	Per Cent.	Per Cent.	Per Cent.
Carbon	0·07	0·03	0·04
Silicon	0·06	trace	trace
Manganese	0·10	0·27	0·28
Phosphorus	0·01	0·016	0·028
Sulphur	0·02	0·02	0·05
Copper	0·015	0·08	0·09

From the analyses of the plate and the fact that the brittleness can be removed by suitable annealing, it is clear that the

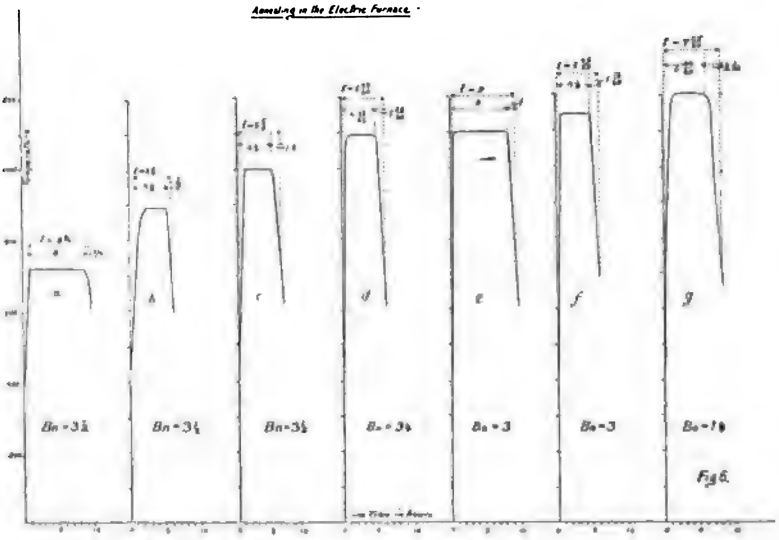
[illegible]

[illegible]

which was wound a spiral coil of nickel, this latter being heated by an electric current; a gas-furnace with forced draught was used for heating some of the specimens, these being enclosed in a crucible, and covered well with a highly refractory claystone powder. The annealing was also partly conducted in a porcelain furnace, the specimens in this case being placed in closed crucibles, and similarly covered with claystone powder. The temperatures during heating up, annealing, and cooling, were carefully measured by means of a Le Chatelier pyrometer, of the type constructed by Messrs. Siemens & Halske. For every experiment a diagram was plotted, on which the time and the respective temperatures were registered. These diagrams are reproduced in Figs. 6 to 9. It would be advisable in future scientific works on the treatment of metals to publish similar diagrams, since by this means a clear representation of the annealing process is obtained. Such expressions as "rapidly heated," "slowly heated," &c., are an imperfect indication of the operation with regard to the sensitiveness of the material to changes seemingly insignificant in character. After annealing, the bending number corresponding to the particular treatment was determined by means of the impact bending test on notched bars of 4 × 6 millimetres in cross section and 60 mm. long (compare Fig. 2). The results obtained are co-ordinated in Fig. 5 in axonometrical representation. On the one horizontal axis is marked the time, t, in hours of the annealing period; upon the other the temperature of annealing, T, is marked. The vertical co-ordinate indicates the bending number B_n. The different values of B_n which have reference to the period of annealing and the temperature form an area which may be termed the bending number area. In Fig. 5 this area is bounded, in the first place, by the heavy lines which denote the change of the bending number at equal temperatures and with varying periods of annealing (lines of equal temperature); and secondly, by the heavy dotted lines which represent the change in the bending number for equal periods of annealing and with varying temperatures (lines of equal periods of annealing). The points enclosed in small circles, and marked a to l on the area, were determined by experiment. The remaining points of the area have been

partly interpolated and partly have had their position assigned as the result of reasoning. Thus it is self-evident that if the annealing period equals 0, and the temperature is 1100°, the bending number must remain unchanged, since this is equivalent to no annealing at all of the material. By following this line of reasoning the whole of the points situated in the area $t = 0$ can be at once determined.

Before considering further the form of the bending number area, it should be observed that the points *a* to *l* represent the result of different series of experiments. The division



of the annealing period *t* into the time spent in heating the specimens from 680° to T, the time during which the temperature T was maintained, and the time necessary for cooling from T to 680°, may be seen on examining the diagrams 6–9, where the same letters corresponding to the same series of experiments are again employed. In the case of the experiments *a* to *g* it was possible, on account of the nicety with which the temperature of the electric furnace could be regulated, to maintain within certain limits an equal rate of heating (the ratio between increase of temperature and increase of time) and the rate of cooling (ratio between decrease of

or cooling below 680° would have any particular influence upon the resulting value B_n. The diagram No. 5 confirms the correctness of this assumption. In diagrams Figs. 6–9, the time in hours is measured on the abscissæ, and the corresponding temperature is measured on the ordinates. The values found from these diagrams for the annealing period *t* were then used in plotting diagram Fig. 5. In Fig. 7, the series *h* and *i*, it should be noted that the test specimens *h* were placed from the very beginning in the porcelain furnace, and together with this latter were gradually heated to about 1200°. At the time corresponding to the point B, the specimen which had been enclosed in a crucible with claystone powder was taken out from the furnace and cooled quickly in the air. On the other hand, the second group, *i*, of test specimens, after enclosing in the crucible were placed in the highly heated furnace at the moment of time corresponding to point B. The heating was therefore very rapid, the furnace being maintained for half-an-hour at the high temperature of 1200°. It was then allowed to cool slowly in the furnace. The test specimens *l* were heated in a crucible, being packed in with claystone in the forced-draught furnace to a temperature of 1450°. Two of the bars were cooled rapidly in the air, while two others were cooled slowly in the furnace. In both cases the bending number was equal, being 0 to ½. Two more of the bars were quenched in water from 1450°, with the result that $B_n = 1\frac{1}{2}$. This result is not noted on diagram 5, but will be utilised later on. To form an idea of the trustworthiness of the impact bending tests on notched bars, the individual values obtained for B_n are arranged in tabular form (Table III.), from which it will be seen that in spite of the somewhat primitive mode of operating them, the repeated tests give bending numbers in which there is little or no variation. It may be assumed, therefore, that these are sufficiently exact for the present purpose.

Referring now to diagram Fig. 5, what does this show? Up to 1000° the heavy lines of equal temperature run parallel to the plane of the axes of time and temperature. The annealing period at this temperature can therefore extend over nine hours without sensibly diminishing the bending number; in other words, without causing an increase in the degree of brittleness. The

line representing 1100°, on the other hand, already declines downwards when the annealing period has exceeded six hours. If the period is extended to nine hours, the bending number falls from 3½ to 3. It declines still more rapidly at 1150°, falling to 3 at the end of six hours. The curve for 1200° gives a value of 1½ for the bending number after annealing for seven and a half hours, and it continues to fall till, at the end of thirteen and a half hours, it reaches 0 to ½. By this means a degree of brittleness was produced in the material such that notched specimens gave way at the first blow or broke off short. By this treatment, then, a brittleness was produced similar to that possessed by the boiler plate under discussion when in its state as delivered to the laboratory. The still longer annealing period at a temperature of 1200°, say for twenty-nine hours, does not increase the brittleness, at least not to an extent that can be determined by the measurement employed. From this it appears that at the end of thirteen and a half hours the maximum state of brittleness is reached. By heating to above 1200° this result is obtained still more rapidly. Thus an annealing period of a quarter of an hour at 1450° is sufficient to induce the maximum degree of brittleness, that is, to give the minimum value of 0 to ½ for the bending number.

The latter result can cause no surprise, for this will be recognised as an evident case of overheating. But that annealing temperatures of 1200° or even 1100° should be capable of producing incipient characteristics of overheating was hitherto unknown, and the avoidance of protracted annealing at temperatures over 1100° is obligatory, if importance is attached to the production of a material with the lowest possible degree of brittleness. In annealing plates or wire, therefore, these conditions must be taken into account, and the neglect of this precaution has doubtless led to the instances of overheating which are met with in practice, and have been unable to be satisfactorily accounted for. It is not, of course, to be supposed that from diagram Fig. 5 the practical steelmaker will be able at once to inform himself of the exact time necessary for the annealing operation. The intended effect might not always be produced. It must be borne in mind that the experiments were carried out with comparatively small test specimens which required only a very

hours, at temperatures between 700° and 890°, a diminution of the bending number does not occur. On the contrary the steel has a higher bending number, namely 4, as compared to $3\frac{1}{2}$ in the rolled state.

This shows that the lowest degree of brittleness, that is, the highest bending number, is not attained in mild steel by rolling, but that it can be reduced by a further small amount by prolonged annealing at the above-mentioned temperature.*

If a comparatively short annealing period at over 1000° reduces the bending number, and on the other band a very much

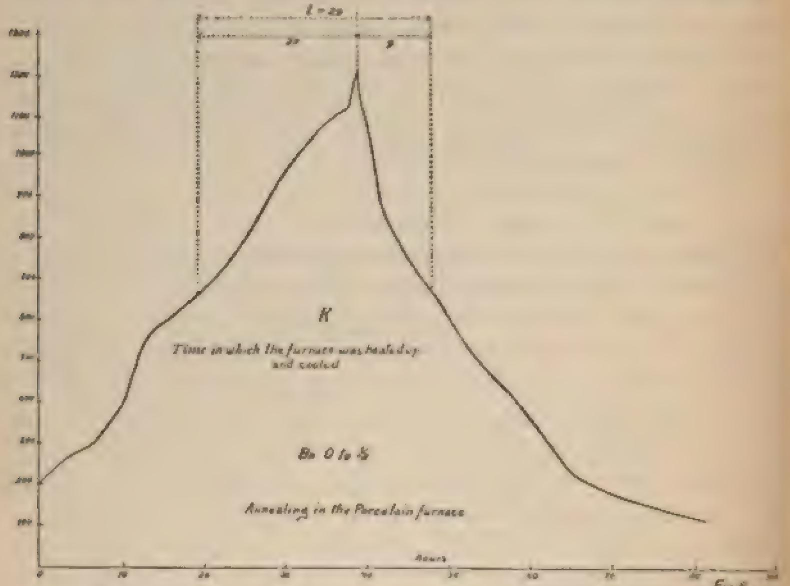


Fig. 5.

prolonged annealing at 700° to 890° does not cause any such diminution, there must exist at some point between 1100° and 890° a temperature limit T1, above which the bending number decreases as the annealing period is extended, but below which even a protracted annealing is without influence. The exact value for T1 cannot be determined by means of the present experiments, but it probably lies between 900° and 1100° C.

Fig. 5 refers only to the material S 660. Several test pieces

* This is not in accordance with Mr. Stead's observations.

TABLE V.

Initial State of Test Piece.	Kind of Subsequent Annealing.	No. of Test Bar.	Bending No. B_n.	Average B_n.
Overheated in the porcelain furnace. Diagram of heating and cooling is essentially the same as that shown in Fig. 8.	Not annealed	119 123 139 140	0 to ½ 0 to ½ ½ 0 to ½	0 to ½
	Annealed for half-an-hour at 600° C.	120 121 122 123	½ ½ ½ ½	½
	Annealed for half-an-hour at 700° C.	124 125 126 127	½ ½ ½ to 1 ½	½
	Annealed for half-an-hour at 800° C.	129 130 131 132	½ ½ ½ ½	½
	Annealed for five hours at 800° C.	146 147 149 150	½ ½ ½ put aside, not having the right dimensions	½
	Annealed for half-an-hour at 850° C.	142 143 144 145	½ ½+ 1+ ½	½+
	Annealed for half-an-hour at 900° C.	133 134 135 136	3 3 3 3½	3
	Annealed for half-an-hour at 1100° C.	137 138 140 141	3 3 3½ 3	3
	Annealed uninterruptedly for six days at temperatures between 700° and 850° C. .	159 161 163 160 164	3 3¾ to 4 4 4½ 3	3¾

or by quenching, can be got rid of by annealing for a considerably shorter time, and at much lower temperatures, than that due to overheating. This may be regarded as a determining factor in diagnosing of overheated steel.

The law relating to the overheating of mild steel, which is expressed in Fig. 5, assumes that cooling from the temperature of overheating does not take place too suddenly, in particular that it is not produced by quenching. The effect of quenching subsequent to overheating requires further elucidation. To judge from the single experiment tried, the quenching of a mild steel bar in water after overheating produces a less degree of brittleness than if cooling had proceeded slowly. (See Table VI.)

TABLE VI.

Heating.	Cooling.	No. of Test Bar.	Bending No. B_u.	Average B_n.
Heated in 14½ minutes to 1450° C.	Cooled slowly in the furnace.	17 18	0 to ½ 0 to ½	0 to ½
	Cooled rapidly in the air.	19 20	0 to ½ 0 to ½	0 to ½
	Quenched in water at 21° C.	21 22	1½ 1½	1½

In other respects the rate of cooling appears to exercise no particular influence upon the bending number, that is, the degree of brittleness as is shown in the series *l* of experiments in Tables III. and VI.

Here is an instance in which quenching has produced a lesser degree of brittleness in mild steel than a slower cooling, which, at all events, may be regarded as a noteworthy occurrence.

Another question then presents itself, namely, to what extent the degree of brittleness is influenced, if, after overheating, the specimen, instead of being left undisturbed to cool, were forged or rolled. On this point experience has already taught something. With each welding operation a considerable degree of brittleness would be developed, were it not that, in consequence of the hammering, the effect of the previous overheating was neutralised. An experiment on these lines confirmed the fact that mild steel which has been annealed sufficiently long at a high

brittleness, and give the exceptionally high bending number 4. The fracture is extremely coarse-grained, if care is taken that a considerable change of form does not occur previous to fracture by deeply notching a thin test bar on both sides, and breaking it with a good blow. On the other hand, mild steel that has been much overheated, and exhibits the highest degree of brittleness with a bending number of 0 to $\frac{1}{2}$, may show a dull fracture if the thin bars of 4×6 mm. in cross section are not previously notched, but are broken gradually by bending backwards and forwards. If one takes as a standard method the impact bending test on notched bars of the same dimensions given in the earlier portion of this paper, a coarse grain will result each time if the material is in the most extreme state of overheating. The transition stages, however, from this to a less degree of overheating are not easily traceable in the fracture of the test specimens. Coarse fracture in mild steel can therefore be regarded as possible evidence of overheating, but is not to be considered as a decisive proof.

Even with fractures produced by similar means as by the bending test for determining the bending number the degree of brittleness is not proportional to the size of the grain, at least not in the various mild steels which the author has up to now investigated.

The fractured grain which is visible on newly fractured surfaces must not by any means, as unfortunately often occurs, be confounded with the "size of grain" of the steel. If low-carbon mild steel is polished and afterwards etched, it will be observed on examination under the microscope that, apart from very minute inclusions of a structural component containing carbon (pearlite), the material is similar in structure to marble built up entirely of small crystal grains of iron (ferrite). The size of these crystal grains of ferrite, commonly called the size of the ferrite grains, doubtless has a certain relation to the type of grain in fractures, but it by no means forms a standard by which the latter can be judged. By the employment of a different method of fracturing an entirely different fracture grain can be produced in one and the same material, though the size of grain of the ferrite is the same. Quite apart from this, however, the fracture grain in the case of similar

of the ferrite and pearlite grains, and the property of tenacity of the respective steel. These all are at fault, for the reason that they take no account of the far more important influence of the first crystallisation just now described. Further confusion in the opinions regarding the influence of the size of ferrite grains on the mechanical properties of the iron seems to have had its origin in the inadequate definition of the idea of ferrite grain. On etching a polished section of a specimen of mild steel with a suitable etching medium (nitric acid according to Stead, dilute copper ammonia chloride according to Heyn) the boundaries of the different grains usually become well-defined. With a strong magnification, say with a linear magnification of 1600, very minute geometrical figures may be detected (see also Stead on "Crystalline Structure of Iron and Steel"), which the author terms etching figures, according to the precedent of mineralogists, especially Baumhauer.* Since the neighbouring crystal grains of the ferrite in general lie in every conceivable position with respect to the surface of the polished specimen, and since it is known from the investigations of Baumhauer that on crystallographically equivalent surfaces the etching figures are alike in regard to form and position, but are unlike on crystallographically dissimilar surfaces, hence there must exist at the places on the polished surface, where the etching figures suddenly assume a different position and form, a line of demarcation (compare photomicrograph No. 2, Plate II., on which portions of three grains are illustrated). Within this line lies the ferrite grain, and its size is indicated by the size of the enclosed area. By this means a scientifically exact definition of the idea "ferrite grain" is obtained, and also of the conception "size of the ferrite grain." Even though in many cases the confining walls of the grain may be distinguished in a more simple manner, yet on the other hand these more simple methods are apt to lead to illusory results which would be avoided if the etching figures were taken as a criterion in doubtful cases. In general the area of grain surfaces which are in juxtaposition varies, but this is only natural, since the grains are cut through at different points by the section. By taking a sufficiently

* See *Mitteilungen der Königlichen Technischen Versuchsanstalt*, Berlin 1898, E. Heyn. *Mikroskopische Untersuchungen an tief geätzten Eisenschliffen.*

small dimensions be regarded as characteristic of a low degree of brittleness.

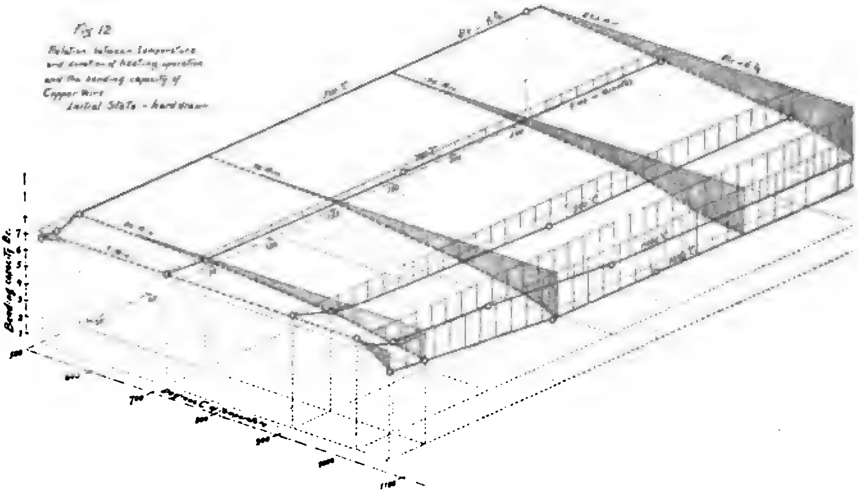
It was stated by Mr. Stead, that in the cases where he was able to determine the brittleness in the material, the ferrite grains were of considerable size, and that grains in juxtaposition approximately resembled each other in their crystallographical orientation with reference to the plane of the polished section. In mild steel, which is built up of coarse ferrite grains, but exhibits no brittleness, on the other hand, the orientation of crystal grains was said to be haphazard. The author has studied this question more closely with the aid of etching figures, which display beyond question the orientation of the crystal grains, and also with the aid of the slip-bands * of Ewing and Rosenhain, but has never been able to detect a difference in the orientation of the ferrite grains, as said to exist by Mr. Stead. In both cases, whether the mild steel was brittle or not, the microscopic characteristics observed were the same, and there was no indication that the orientation of the ferrite grains in juxtaposition in brittle material was at all similar. But the author has certainly noted a similar appearance of almost regular occurrence in the case of overheated copper, resembling that mentioned by Mr. Stead as occurring in overheated mild steel. It cannot be expected that in iron the similar orientation of the ferrite grains, even if it might have been existent at the temperature of overheating, would not have been disturbed during cooling, especially as the conditions of cooling, as will be shown further on, exercise a determining influence on the size of the ferrite grains, and as the change of orientation most probably goes hand in hand with the variation of their size.

For the present, therefore, the result of the author's experiments shows that there exists no assured microscopic characteristic by which the overheating of mild steel might be detected. Ferrite grains of coarse dimensions may in the most favourable case afford an indication that overheating may perhaps have

* A circumstance might be mentioned here which requires a fuller investigation. It seemed to the author that in mild steel of a low brittleness but with ferrite grains of large size, the slip-bands occurred only in the case of violent distortion and then were crooked, while in the overheated material they appeared after a much less distortion and were rectilinear. Since this side of the question was not tested systematically, this distinction can only be accepted as a supposition.

side being struck until fracture occurred. Every time of bending to 90° and every time of re-straightening was counted as one bending operation, and the sum of these until fracture took place is denoted by the sign B_c, and is hereafter called the bending capacity.

Before making the bending test the wires were annealed at different temperatures and for varying lengths of time, and after annealing all the test pieces were quenched in water. The relation between the annealing period, annealing temperature, and bending capacity, B_c, is represented clearly in diagram Fig. 12, in the same manner as the results for mild steel are



shown in Fig. 5. From the diagram and from the further experiments, which need not be given here in detail, the following laws for copper were determined:—

a. As the result of annealing at above 500° C., the bending capacity of the wire is reduced, the reduction being greater in proportion as the temperature is higher. A comparatively short annealing period suffices to produce the effect. The difference between the highest and lowest bending capacity corresponds to the values $B_c = 6\frac{3}{4}$ and $B_c = 4$. Annealing at 500° for a short period only does not suffice to eliminate the effect of cold-drawing, which explains the initial rise of the curve for 500° in Fig. 12. After annealing for twenty-six minutes, the maximum

Thus it will be seen from Table VII. that from the average size of grain the kind of annealing to which the material was subjected may with some certainty be conjectured. The bending capacity does not bear a simple ratio to the average size of grain, but in general it decreases with the growth of the grain.

It was further observable that the increase of average size of grain was accompanied by numerous twin growths, and that the twin lamellæ lay perpendicular to the surface of the wire in a remarkable number of instances. In the cases where coarse copper grains were formed, the impression often gained, on examining these under the microscope, was that the coarse crystals had been formed from smaller crystals by a gradual turning movement of the latter into a similar crystallographical orientation. It was often difficult to determine the limits of the grains by means of etching figures, because they often differed only very minutely as regards position and form in the case of grains in juxtaposition. This fact is somewhat in accordance with the statement of Mr. Stead regarding ferrite grains in brittle mild steel.

The laws relating to the overheating of copper contained in paragraphs *a* to *c* are surprising in their simplicity as compared to those for mild steel given previously. The notable differences in this respect between the two metals would beyond doubt form a fitting subject for further investigation, since they are of a far-reaching nature. But the cause of them may be sought for with some degree of certainty in the following facts. Copper, after solidifying, cools down without exhibiting any noteworthy phenomena. Low-carbon mild steel, on the other hand, shows below the point of solidification two other transition points, one of which is about 900° C., and the other about 775° C. At the first transition stage a crystallisation occurs, but with copper no such point of crystallisation exists. If then, during the cooling of low-carbon mild steel, crystallisation takes place at 900°, the size of the crystals produced (the ferrite grain) must be influenced by the rate at which crystallising proceeds. For example, if a solution of alum is left alone a long time to crystallise, beautiful large crystals will grow, but if the process is allowed to proceed rapidly, a large number of small crystals will be obtained. It is therefore only reasonable to expect that

was determined, that the size of grain increases with the period of cooling. The absolute values are however different for the zones, being found to depend in a great degree on the initial state from which the metal is annealed. Thus the two points a_r and a_k, in Fig. 13, denote the size of grain in the surface and core zones respectively, which was obtained when the material, before heating up, had already undergone one annealing. Both points lie outside of the line traced for the test pieces heated for the first time.

The law represented by Fig. 13 was found to be confirmed in the case of all kinds of mild steel. Even though it may not be possible to foretell what will be the absolute value of the size of the ferrite grains produced by a definite cooling period, yet it may be learnt from a study of Fig. 13 in what direction the influence of cooling makes itself felt. The manner in which the most minute variations in the chemical composition can influence the absolute value of the size of the grains obtained by definite cooling periods is proved, for example, by the fact that a Swedish mild steel, which Mr. Brinell very kindly presented to the Testing Institution at Charlottenburg, showed after heating for half-an-hour to 1100°, and after cooling from that point to 680°, in seven hours an average size of grain of 47,817 μ^2. This exceeded by ten times the value of the grains obtained by the same treatment in the material of the boiler plate. For comparison, the analysis of the Swedish iron is given below:—

	Per Cent.
Carbon	0·08
Silicon	0·005
Manganese	0·08
Phosphorus	0·021
Sulphur	0·014

Compare the analysis of the boiler plate given on page 80.

It is worthy of mention that the ferrite grains in the boiler plate in the case of every cooling period were equiaxial, while those in the Swedish specimen of mild steel appeared after seven hours' annealing to be distinctly elongated.

Since there exists no transition point in the copper corresponding to that of iron at 900°, the size of grain will not be much affected by the cooling. The cooling of the copper in

2. Prolonged annealing, say uninterrupted for fourteen days, at temperatures between 700° and 890°, produces no increase in the brittleness. In such cases where the brittleness of the material in its initial state was not yet at the lowest degree possible, by this treatment the lowest degree of brittleness will be attained.

3. Between 1100° and 900° there exists a temperature limit, above which, if annealing is carried on for a longer period and at an increasing temperature, the degree of brittleness increases. Below this limit, however, this is not the case.

4. Overheating does not only occur at most extreme white heat, but manifests itself already at considerably lower temperatures, which must, however, exceed the temperature limit referred to in (3), the degree being more marked the longer the annealing period.

5. By suitable annealing, the brittleness of overheated low-carbon mild steel can be eliminated. If annealing is carried out at above 900° C., a short period of about half-an-hour is sufficient. Longer annealing must be the more carefully avoided, the more the temperature limit referred to in (3) is exceeded, otherwise the signs of overheating reappear. Below 800° an annealing of even five hours is not sufficient to eliminate the brittleness in overheated low-carbon mild steel, but by annealing of several days' duration, at temperatures between 700° and 850°, this object can be attained.

6. If low-carbon mild steel, which has been annealed for a longer period at a high enough temperature, so that after undisturbed cooling it would show extreme brittleness, is rolled or forged during cooling to bright red-heat, it will exhibit no brittleness when cold.

7. The fracture of overheated low-carbon mild steel generally shows a coarse grain, although this is not necessarily always the case.

8. The single crystal grains of which the structure of the iron is built up, which can be detected under the microscope by suitable etching, are often of considerable dimensions when in the state of overheating. Nevertheless this is not to be considered as proof positive that overheating has taken place, since the method of cooling also exercises a great influence on the size of

DISCUSSION.

Professor H. M. HOWE (New York) thought he could hardly do more than express his thorough admiration of the skill with which Professor Heyn had laid his researches before them. He felt that, without much further study than he had been able to give to the paper, it would not be proper for him to criticise it. He might, however, mention that one of his students (Mr. Morse) had found out, perhaps more fully than Professor Heyn's language might be thought to imply, that at relatively low temperatures the reheating should begin to produce the effect which a high temperature produced more rapidly. Mr. Morse showed very clearly by his micrographs the effect of heating to a relatively low temperature, first for half-an-hour, then for an hour, and then for three hours, but he had not carried on the heating for the long periods which Professor Heyn had shown. But Mr. Morse had shown that the same kind of effect, as far as the microscope would show, was produced at lower temperatures (900° C.) which arose, though much more rapidly, at higher temperatures. He was glad that Professor Heyn supported the discrimination which had been already offered between overheating and burning.

Mr. F. W. HARBORD (Cooper's Hill) said he had read the paper with the very greatest interest, and endorsed it in almost every particular. With reference to the points where Professor Heyn disagreed with Mr. Stead, the latter's experiments were all below 700°, and Professor Heyn's were between 700° and 890° C. Now, they knew how very sensitive steel was to a slight alteration of temperature, and this was quite sufficient to account for a difference in the results. During the last few months some results had been submitted to him of steel treated at lower temperatures than Mr. Stead's, and they completely confirmed Mr. Stead's results—viz. that at very low temperatures the heating of the mild steel would produce the brittleness that Mr. Stead had found. He thought the little difference there was between Professor Heyn and Mr. Stead was simply a matter of

Mr. Stead's sample. Perhaps Mr. Stead's samples were obtained by some such ill-treatment. In this case the samples could no longer be termed steel, though they had been steel. However, it seemed interesting to investigate the real causes of the phenomenon, and it would be a duty to continue experiments so far until Mr. Stead could produce the phenomenon *at will*. Then it would be shown whether this brittleness of Mr. Stead's was a danger for the steel manufacturer, or whether it could only be produced by extreme ill-treatment.

The second of Mr. Stead's samples was less coarse-grained, and showed remarkable rectangular cleavage. The author would like to know the analysis of his sample, especially the percentage of phosphorus, which the author suspected was high. By the affirmative sign with which Mr. Stead replied to his question, the author concluded that his suspicion was true. In this case the sample must be excluded from discussion, since the author's paper did not deal with steels high in phosphorus.

The author fully agreed with Mr. Stead as to the terms *annealing* and *reheating*, and was very sorry to have used the wrong word, owing to his defective knowledge of the English language.

Though there was a certain divergency in some points between Mr. Stead and the author, the latter expressed his hopes that he would be permitted to struggle for truth shoulder to shoulder with this eminent, practical, and learned man.

The PRESIDENT said that the paper was one of conspicuous importance, and it was a matter for regret that their other engagements prevented them from devoting the whole day to its discussion. Their best thanks were due to the author.

The meeting was adjourned until the following day (Thursday).

The PRESIDENT, in opening the meeting, said as there were several members desirous of speaking on this paper who could not do so for lack of time yesterday, he proposed that they should give a quarter of an hour for further discussion, and he called upon Professor Tschernoff, the distinguished Russian metallurgist, to address them.

up for a moment to 900° and allowed to cool in the air. They would see that the bend had now gone round to 180°, which showed the wonderful power of this heat treatment. The microphotographs of these two specimens showed in the one case the characteristic structure of burnt steel, and in the other case a completely restored structure. Mr. Stead had spoken on the previous day of the advantage in forges of reheating of work to 900°. Their own invariable experience was that it was a most excellent practice, and they had themselves adopted this for several months past in the case of important forgings.

The only other thing was an omission, which was that there was no mention made of Mr. Ridsdale's work, and he ought to have been mentioned, and likewise the work of the American investigator, Morse, ought to have had recognition, and some credit given to it in Professor Heyn's paper.

Mr. SANITER (Middlesbrough) said it would be a matter of convenience to readers of the *Journal* if the author would give references showing in which numbers of the *Journal* Mr. Stead's papers were to be found. After reading Professor Heyn's interesting and able paper, he did not see any justification for his remark that "Mr. Stead was led astray by various and insurmountable obstacles when almost within reach of his goal." After re-reading Mr. Stead's papers, it seemed to him (the speaker) that while Professor Heyn's work was an amplification, useful and valuable, of the work of Messrs. Stead, Ridsdale and others on overheating of steel, he had failed altogether to obtain the brittleness which Mr. Stead obtained at a temperature of 700° to 750°. Professor Heyn made some explanation yesterday, that he meant one brittleness and Mr. Stead another brittleness, but they took it that the steel that broke was brittle; there might be minor differences, but the main point was brittleness. As was pointed out by Mr. Stead yesterday, Professor Heyn had been working at a somewhat higher temperature. He (the speaker) noted, on referring to Mr. Stead's paper on the subject, that while he got an enlarging of the grain from 700° to 750°, he also got a certain amount of refining at 800°, which was within the temperature worked at by Professor

to 750° was caused by the removal of this carbon. What suggested this to his mind was Mr. Stead's experiments, made some years ago, of decarburising cast iron which showed a columnar structure. In a fracture of this steel with a brittle surface they found that columnar structure. With reference to what Professor Heyn said about only getting enormous crystals in furnace bears, everybody knew that in Siemens furnace bottoms such crystals were always found, but they were very high in carbon and other impurities, and not comparable at all with the metals with which Mr. Stead had worked.

The PRESIDENT said it was necessary now to close the discussion, and he would be glad if Professor Heyn would put into writing anything he had to say in reply.

CORRESPONDENCE.

Mr. T. VAUGHAN HUGHES (Birmingham) subsequently wrote that as a further contribution to the peculiarities of ingot iron or mild steel the author's paper was of considerable value, but one could not help noticing the omission of any reference to Mr. Ridsdale's paper on "The Correct Treatment of Steel." From his (Mr. T. Vaughan Hughes') experience and researches Mr. Ridsdale's paper was of great practical importance, for the simple reason that his results were obtained on a large working scale, and not based on deductions from small masses of metal, such as Professor Heyn had used in his investigations. He would suggest, therefore, that as Professor Heyn had at his command the resources of the Charlottenburg institution, experiments should be repeated on larger masses of steel.

He (Mr. Hughes) had some time ago a problem to attack similar to Professor Heyn's, and he soon found that the outside skin and the internal layers of the metal were in a different chemico-physical state, such as described by Professor Heyn in his bars. He was unable to adopt the methods of planing and so on resorted to by Professor Heyn, but found that for the purpose of his investigation the Brinell number gave very useful figures,

a material consisting of the differences between pure iron and the test pieces. He was in agreement with Professor Heyn as to the use of the expressions "rapid heating" and "slow heating" in work of this kind. Everything, in his opinion, depended on the time occupied in heating and the exact manner in which it was done, otherwise the results were indefinite and misleading. In this connection, he would like to ask Professor Heyn what he meant when he spoke of a "comparatively short annealing period at over 100° C." With regard to the temperature of 900° and 1100°, no doubt Professor Heyn would find that steels of different makes required different treatment, and that every maker and user of a mild steel would be obliged to investigate the best conditions and best temperature for producing the best result under the conditions obtaining in his works. With regard to the size of ferrite grains, he (Mr. Hughes) did not see that there was any advantage to be gained by adopting methods other than those described by Mr. Stead and Mr. Ridsdale. He would suggest that a method similar to that recognised among microscopists for determining the average admixture of an adulterated sample be applied, namely, that of taking a given number of fields in a section, and determining in each the largest sized grain in the fields, taking the average of them as the average size of grain. Of course, this method did not presume to solve the difficulty of determining the largest grain, but it did seem to him that some recognised procedure should be adopted for the present, because he had found in his own work that taking a hundred or more fields in the same zone of a billet or bar he would perhaps come across one grain which would be double or treble the size of any others. Some figure should therefore be given for the grain size which should bear some relation to the number of smaller grains existing in a section. Then, again, as to the magnification for determining the grain size, he found 200 linear convenient.

The author stated that the bending number could not be appreciably affected by slow or rapid cooling from the temperature of overheating, but his results showed that the Brinell number was affected. With regard to continued annealing, as he had suggested above, it was a question of alteration in the composition or volume of the eutectics in which the grains

copper, which had no transformation points between the ordinary temperature and the melting-point, followed simple laws in the development of their crystalline grain. Probably every allotropic variety of iron tended individually to follow these same laws. Now the ferrite grain, as defined by Professor Heyn with the aid of his reagent, double chloride of copper and ammonium, was the grain of alpha-iron; the grain which was developed by annealing at high temperature was the grain of gamma-iron. These were two different grains, and it appeared fully established, notably by the experiments of the author and by the consequences of overheating, that these two kinds of grain exercised their influence upon the mechanical properties of the metal after cooling. The delicate question was to discover whether there existed a relationship between the structures of gamma-iron and alpha-iron, and what this relationship was. This question had been the subject of investigation by Mr. Cartaud and by the writer in their researches upon the crystallography of iron by etchings within the zone of the stability of gamma-iron, and by the annealing of surfaces previously polished. The etching with melted chloride of calcium formerly proposed by Mr. Saniter had the same object. Nevertheless the problem had not been definitely solved. The difficulty was to distinguish the different structural outlines when developed upon the same specimen, and to learn the nature of each. A good method was still wanting which would permit to trace with certainty the respective structural outlines of alpha-iron and of gamma-iron. Upon the invention of some such method the progress of our theoretical knowledge of the annealing of steel would appear to depend. But it was not necessary to await this, in order to solve experimentally the practical problem of annealing, inspired by the example of Professor Heyn.

Mr. C. H. Ridsdale (Middlesbrough) wrote: Professor Heyn had dealt with a subject of very great importance and one on which a good deal had been already written; and as the knowledge obtained was beginning to be generally accepted and acted on by practical men, in order to avoid all confusion or a feeling of uncertainty arising, it was highly desirable that no fresh communica-

confined to any one make of steel." * Thus, even had it been practicable for the author to attain a greater degree of accuracy than that already determined, he had, unfortunately, frustrated the very object sought, by working on only two samples of material, and selecting these not of medium softness or purity, but both near the extreme practicably obtainable, and hence by no means representative of ordinary mild steel; as well as by showing no adjustment in the diagram constructed (Fig. 5, p. 83) either for varying composition or section.† Any laws framed on data obtained from such narrow bases could only be relied on as correct for the particular samples worked with, and would thus be of no value for general practical purposes, and in order to supply data in the terms of accuracy apparently intended, a separate diagram would be needed for steel of each composition and section comprised within the ranges ordinarily used. They had seen from the foregoing what limits of exactitude were practicable for the avoidance in the first place of wrong treatment. Then, as to the cure, which was perhaps at present the outcome of most practical importance to the varied industries, this, too, as already known, was about as clear and simple as they could expect, viz. that almost every form of brittleness, whether due to either type of overheating or cold or blue heat working, could be removed, or its absence ensured sufficiently for practical purposes by very rapid heating to preferably not less than 900° C., or not more than 1100° C., for only a short time, in many cases only for a minute or two. He believed he was the first (and he saw Mr. Stead had called attention to the fact in his remarks at Düsseldorf) to show and lay stress on this. He trusted, therefore, he might be allowed to criticise the paper somewhat closely on some points, all his remarks, appreciating it as he did, being offered in a perfectly courteous and friendly spirit.

The paper led essentially to two issues. On the one hand, that in which from results obtained the author drew conclusions opposed to those resulting from former work (directed chiefly against Mr. Stead), as to at how low temperature the growth of grain commenced, and contended that prolonged annealing at

* "Practical Microscopic Analysis," *Journal of the Iron and Steel Institute*, 1899, No. II. p. 109.

† *Ibid.*, p. 113.

With regard to the second issue, Professor Heyn's work would be welcomed as a confirmation, so far as it went, of already well-known and published work and conclusions, since the more independent observations were made the better.

He (the writer) had himself read a series of papers before this Institute, dealing with the effect of various thermal and mechanical treatment on mild steel, and which in his references he would designate I., II., and III., the first illustrating these effects by means (chiefly fractures by sudden shock) and terms employed and appreciated by practical men, the second by means (photomicrographs) and terms generally designated as "scientific," and the third entering with more detail into the practical application to individual industries of the principles up to date. He thought, however, that Professor Heyn could not be aware of these or he would no doubt have referred to them, and, under the circumstances, it was remarkable how much of the author's paper consisted of matters which, from the way they were put forward, he clearly regarded as originating with himself, but which in idea, and often even in expression, had been previously clearly stated by others, including himself, sometimes indeed reading almost like extracts from the above papers. So much was this so that, so far as he could see, he feared there was not one point or conclusion named, on which they were both agreed, of which the ideas had not been thoroughly traversed and with the deductions already published by the writer himself, in some cases the matter having been carried considerably further than in the author's paper. It would take up too much space to discuss fully every point, but as it would no doubt not only be interesting to the author if (together with general comments) he included a few citations of the nature referred to, but also, which was of more importance, emphasised still further the reliability for practical use of the data in question, he would do so, giving them for the most part from the earliest paper, though, of course, they had been reiterated in the later papers. He might just say that he felt sure that, now his attention was called to it, Professor Heyn would wish, in the work he had stated his intention of publishing shortly, to make due acknowledgment, not only of these, but of other researches in the same direction—Campion's, &c.

As regarded the definitions and distinction made between overheating and burning, and the resulting alterations in structure, the author clearly referred to the difference between heating to such an extent—particularly so intensely—as to result, at least towards the edges, in the carbon being all burnt out, and free oxide of iron being left between some of the grains, so that toughness could not be restored to that part by reheating; as compared with the lesser degree of overheating where no free oxide of iron was left and toughness could be restored, *i.e.* the mass had suffered no appreciable chemical alteration in its ultimate composition, the change being essentially structural.

He could hardly be understood to imply that in pieces previously tough, in which overheating had induced distinct brittleness, there was no chemical change whatever in any portion, such as a gradual diminution in the carbon in the most overheated parts. The writer had himself shown clearly the distinction in character of the two degrees of overheating.

HEYN.

P. 74. "The term 'to burn' conveys the idea of . . . a taking up of oxygen by the metal. . . . The author accordingly defines burning as a chemical change in metals, especially with respect to the taking up of oxygen by them, this . . . of course affecting their physical properties. 'Overheating,' on the other hand, he considers to mean an increase of brittleness . . . brought about by heating under special conditions, but working no change in chemical composition."

RIDSDALE.

* I. P. 233. "With the exception of Nos. 9 and 10, 40 to 50 per cent. of the original carbon has been removed in working up, which points strongly to excessive or prolonged overheating . . ." (overheated but not burnt).

II. P. 107. "Normal steel . . . heated . . . near to welding but not to burning . . . became very brittle . . . reheating . . . restored the toughness. . . ."

III. P. 128. Refers to the photographs illustrating par. 15. "The different stages of the transformation from tough to brittle steel. . . . In prolonged or excessively heated samples the growth of the grains or carbonless band, the gradual penetration of oxide cracks or loosening of the junctions."

† See also further on references to "soaking" as compared with heating to "too high a temperature."

* See note, p. 125.

† See also pp. 170, 171, and 172, *Discussion*—Stead's paper on "Brittleness produced in Soft Steel by Annealing"; "Restoration of Toughness," *Journal of the Iron and Steel Institute*, 1898, No. II. pp. 168 and 172.

HEYN.

P. 88. "But that annealing temperatures of 1200° or even 1100° should be capable of producing incipient characteristics of overheating was hitherto unknown, and the avoidance of protracted annealing at temperatures over 1100° is obligatory if importance is attached to the production of a material with the lowest possible degree of brittleness."

RIDSDALE.

* P. 169.

Experiments.	Time.	Temperature, approximately.	Result.
"Stead . .	48 hours.	Low red heat, 600° to 700° C.	Large grains, occasional brittleness.
Ridsdale .	3½ hours.	Ingot furnace, say 1100° to 1200° C.	Large grains, pronounced brittleness."
Ridsdale .	3 to 5 mins.	Nearly welding, 1250° to 1350° C.	

The temperatures and lengths of time given by the author to which steel might be subjected before producing brittleness were far too high for general use. On Diagram, Fig. 5, also p. 86, *h* and *i*, and p. 88, it was shown that maximum brittleness was not reached till thirteen and a half hours at 1200° C.; on p. 86, that up to 1000° C. the annealing period could extend over nine hours without causing brittleness, or, p. 88, for six hours at 1100° C.; and that even seven and a half hours at 1200° C. only reduced the bending number to one half that for good tough steel. This could apply only to his samples, and if steel users were to act regularly in practice on such statements it would in many cases lead to disastrous results.

From Diagram III., p. 73 (III.),† shown by the writer, it was clear that detrimental growth of grain occurred if soft steel was heated at all long to its critical temperature (which was shown, p. 67, to be usually about 1000° C.) and allowed to cool slowly.

In referring to one of Mr. Stead's papers, the author virtually quoted the title of one of the writer's papers—viz. "Brittleness in Mild Steel" (the inverted commas were the author's), the writer's paper being "Brittleness in Soft Steel." The nearest approach in title of any of Mr. Stead's papers was "Brittleness produced in Soft Steel by Annealing." The author rather made

* See note, p. 125.

† III. "Correct Treatment of Steel," *Journal of the Iron and Steel Institute*, pp. 67 and 73.

HEYN.

"At 800° an annealing period of five hours is not sufficient to raise the bending number appreciably."

P. 91. With ". . . six days . . . between 700° and 850° the brittleness disappears entirely. . . ."

P. 93. "It is noteworthy that by a short annealing of, say, half-an-hour at 1100° C., for instance, a temperature at which, after a fairly long annealing, signs of overheating" reappear, "the influence of overheating can be again removed."*

But for longer periods "the signs of overheating appear once more. . . ."

RIDSDALE.

(900° to 950° C.), both when cooled slowly and when chilled in water (Figs. 29 and 31, Plate III.). In both cases toughness was restored, and they showed "a decidedly finer fracture."

The author has frequently met with pronounced restoration of toughness in overheated steel at temperatures between 700° and 850° C. in small pieces in a few minutes, but agrees that it is better to heat to 900° C. or over. See III., Diagrams III. and IV., pp. 73 and 78.

* III. On p. 71, discussing the various objects of annealing, it is shown that this is done whether it is heated to a pretty high temperature, say 950° to 1000°, or to lower temperatures. On studying Diagram III. (same page), it will be seen to be clearly shown that the only limit of temperature and time is where the grain begins to grow again, this being shown, even after being heated to beyond critical point, viz. to about 1100° C., still to be smaller than before so reheating, provided the period is not too long; but with long periods too great regrowth of grain would occur, and he would regard half-an-hour as decidedly too long at this temperature.

III. P. 86 shows how annealing, "if carried at all to excess as to temperature or length of time, will undo the good of reheating by promoting the growth of grain."

The author said: "A distinctive characteristic of the brittleness produced by overheating is the difficulty with which this brittleness is removed by annealing;" and that "Brittleness produced by cold working . . . at blue heat . . . can be got rid of by annealing for a considerably shorter time and at much lower temperatures. . . . This may be regarded as a determining factor for the diagnose of overheated steel. . . ." It was quite true that ordinary rolling hardness could usually be got rid of by such comparatively slight reheating, as also the hardness produced by working at blue heat or cold, if no permanent cracks were present; see II., p. 128. But if any

* See note, p. 125.

HEYN.

With each welding operation a considerable degree of brittleness would be developed were it not that, in consequence of the hammering, the effect of previous overheating was neutralised."

RIDSDALE.

high temperature without subsequent work to destroy that effect," nine samples shown—see Plate VI., *i.e.* illustrating not only the coarser structure produced, but also the weakness.

P. 232. ". . . The less the work . . . put on . . . in order to complete the rolling, the less completely the (initial coarse) structure will be destroyed. . ."

P. 233. "Supposing a link is being welded, some of the adjoining links are almost certain to be raised to or near welding temperature, and should they remain at this temperature for a few minutes, as they will cool with no work on them, work being only at the actual weld, we can easily understand how, when subjected to a sudden jerk, a fracture . . . may result."

HEYN.

Hence—

P. 95. "If it has been forged down to a bright red heat" it "does not exhibit these characteristics."

RIDSDALE.

P. 229. "From these tests it will be seen that work down to low red completely restores the toughness of the steel. . . ."

P. 233. "Brittleness . . . may be produced . . . by high initial temperature (short of burning) with no work below a yellow or BRIGHT red heat . . . whether cooled slowly or rapidly. . . ."

P. 234. "To avoid brittleness . . . work should be continued down to red heat."

He had shown that work was necessary to at least below 1000° C.

* P. 168. Footnote. "This confirmed what the writer had said in his paper . . . as to continuing work down to red heat, but not blue heat. In fact, they wanted to keep between the two extremes, say 1000° C. and 750° C."

HEYN.

P. 95 mentions a bar about 1 inch square heated 14 minutes on smith's hearth at white heat. The part forged only till bright red hot, but to about one-fifth the original sectional area, then let cool in air, was pretty tough. The part allowed to cool undisturbed was brittle.

RIDSDALE.

Amply demonstrates this fact from sample 26 *a*, I. p. 229, up to sample 44, p. 231; describes many bars overheated and cooled (undisturbed) both slowly and quickly (chilled), which were brittle.

HEYN.

P. 95. "From these experiments a result of considerable importance is

RIDSDALE.

To some extent this is so:—

III. P. 55. "The maker controls the

* See note, p. 125.

Heyn.	Ridsdale.
if in all cases the same method is employed and" provided "a considerable change of form does not occur previous to fracture . . . breaking it with a good blow."	not specially trained in the appreciation of such evidence as the microscope affords. . . ." * I. P. 232. "As regards the actual fracturing of pieces, . . . a great deal depends on the suddenness of the shock. . . . If a trial piece once commences to bend, it then becomes much tougher; whereas if it is of sufficient mass and receives a sufficiently smart blow, it will fly with little or no deflection" (examples shown).
P. 96. "Transition stages from . . . the most extreme state of overheating . . . to a less degree . . . are not easily traceable with test specimens" (using the nicking test).	Still by the writer's method this was fairly well traceable; see I. Plates XXX. and XXXI.

The author proceeded: "Coarse fracture can . . . be regarded as possible evidence of overheating, but is not to be considered as decisive proof." This might be correct occasionally, particularly with large sections of very impure steel, but generally speaking it was a strong suggestion of overheating. The point, however, which the previous remarks seemed to bear out was that the absence of coarse fracture was not decisive proof of the absence of overheating. With regard to the relationship between the size of grain as seen under the microscope and the fracture grain, there was no need for the writer to enter controversial ground. Overheating gave clear indications by both methods which broadly corresponded. If the system which he had adopted (II. pp. 109 and 110), of simply comparing samples with standards of proper section, in normal and overheated state, was followed, there was no difficulty in deciding in practice as to whether any sample was overheated or not. Besides, the degree of overheating that caused appreciable brittleness did not show merely a 5 or 10 per cent. increase in size of grain, but more likely 50 to 300 per cent. or more, so it could not easily be mistaken. After his remarks as to the fracture grain being dependent not only upon the method of producing fracture and "the manner in which crystallisation takes place during solidification," unless modified ". . . during cooling . . . by rolling or forging," the author contended, with reference to the connection between the size of the ferrite grain and degree

* See note, p. 125.

HEYN.

depend in a great degree on the state" (temperature or section?) "from which the metal is annealed, and the law was found to be confirmed in . . . all kinds of mild steel."

RIDSDALE.

rapid may break grain up still further."

I. P. 224. Refers to (as being more susceptible to brittleness when hammered at blue heat) "steel which, after it had been at a high temperature, has had very little work put upon it and has then cooled slowly, thus giving time for the formation of crystalline cleavage planes. . . . The higher the initial temperature, or the longer the time exposed to it, the more so, whilst steel that has had a lower initial temperature or more work, *i.e.* has been worked nearer to dull red, or has cooled very rapidly, is less susceptible."

P. 226. "Heating for a short time at an excessive temperature, or soaking for a long time at normal temperatures, . . . followed by very slow cooling, plays a much more important part in the production of such" (brittle) "structures than is yet generally recognised."

In the summary, as would be seen from the foregoing extracts, and as had been previously stated, there was no deduction which could be accepted as correct for general purposes which was new.

It was a pity the author had not, in speaking of brittleness, discriminated between "weakness," *i.e.* brittleness to sudden shock not accompanied by hardness, and brittleness as ordinarily understood (accompanied by hardness); the writer had done this constantly.*

In conclusion, he thought that the giving of actual quotations from the author's and his own papers would show in a more striking manner the corroboration of the important points in question than a mere statement of agreement, and thereby would secure their acceptance in quarters where this had not hitherto been done.

* I. P. 220. "So-called brittleness in soft steel is of course quite distinct from that in high-carbon steel." . . . (In) . . . "the brittleness referred to . . . such steel is still soft and malleable . . . and is simply weak owing to want of intergranular or intercrystalline cohesion."

I. Pp. 230, 231. Connects coarseness of structure and weakness.

might be produced by long heating at a little lower temperature. In that way, he and the author were quite at one. He should like to refer Professor Heyn to several papers which had appeared before that Institute, read by Mr. C. H. Ridsdale of Middlesbrough, who had really very thoroughly studied the subject of brittleness produced by strongly heating soft steel. Mr. Arthur Cooper had given that gentleman every encouragement to follow up those researches, and his papers contained very interesting matter bearing upon this problem. Mr. Ridsdale intended to communicate his views in writing.

The next point he would like to explain was how it was that Professor Heyn obtained no brittleness by annealing at about 700° C. If they looked at his (Mr. Stead's) paper, they would find that he got this crystallised structure at a lower temperature (between 600° and 700°) than Professor Heyn had employed, which was above 700°. His own results were obtained generally on a large practical scale. Large numbers of the bars and sheets were placed in a close annealing furnace such as was used regularly in the annealing of sheets and plates. He had before him a sample proving most conclusively that what he had said was correct. It consisted of a steel sheet which had never been heated to a higher degree than about 700°, and yet it was as brittle as cast iron. He had there also a plate similar to that which Professor Heyn had been investigating, which had got a most extraordinarily coarse crystalline structure on the outside. This plate was brittle and had been close annealed in a furnace at about 700° for about forty-eight hours. The centre part of the plate had a very fine grain structure and was exceedingly tough. The outside, where it came in contact with oxidising influences, was an exceedingly brittle coarse structure. On attempting to bend it, the large crystals broke through their cleavage planes, and fracture, once started, traversed through the bar when subjected to percussive shock.

He had had a bar presented to him by Mr. Byron, Chemist to the Wigan Coal and Iron Company. It was a section of a two-inch tie-bar of an open-hearth furnace. It had probably been red hot for about two and a half years, and during that time it had developed a most extraordinary brittleness, and a

suggest that in future in every forge and blacksmith's shop, after forging the material, it should be returned to a furnace and heated to 900° C. in as short a time as possible. It should not be cooled in the furnace, but be withdrawn and allowed to cool in the air. Many of the fractures he had come across in steel and iron would not have occurred had the material been subjected to that simple treatment. It was not necessary to put it into an annealing furnace and then heat up and cool down slowly, which was a barbarous system, suitable perhaps for castings, but rarely for forgings, unless the material was naturally much harder than was required.

Several of his friends were going to work between this time and the May meeting to put thoroughly to further experimental test the value of proper heat treatment.

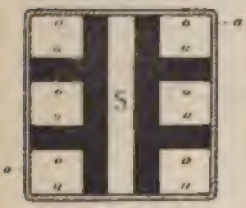
Mr. Westgarth of Middlesbrough had arranged to subject portions of large forgings to special experiment, and was not only going to test them in every possible way by the usual methods, but subject them to vibratory strains and stresses, and he also intended to correlate the heat treatment structure and every mechanical property. Mr. Harbord was also following up a research of a similar kind, and Mr. Lange was also inspired with a similar feeling and was quite convinced that a research of that kind should be done particularly on large masses.

He had some time previously made experiments upon overheating both mild and other steels, and had found that unless disintegration had actually occurred, re-heating invariably restored the good qualities. He was satisfied that if steel were subjected to proper heat treatment one should hear less frequently of mysterious and unaccountable fractures. It was to be hoped that in future such simple precautions above referred to would be taken.

In conclusion, he must acknowledge with gratitude the work of Professor Heyn. It contained much useful matter and was a most valuable contribution to the science of metallography.

Professor HEYN, in reply, regretted that he was not able to furnish the details requested by Mr. Lange relating to the manufacture and previous treatment of the boiler plate. Mr. Lange had found from his experiments that bending tests were a suitable

layer had perhaps become brittle, and that the effect of this had been neutralised in consequence of notching. In reply he would say that all his experiments had been regularly controlled by the use of the microscope, in order to make quite sure that no subsidiary occurrences could influence the results owing to any variation in the structure at different parts of the cross-section. In the case under consideration, it had occurred that the surface metal, annealed for days together at the above temperature, had become roughened owing to the formation of scale. The roughnesses were of such a nature that they might in any case have produced an effect similar to notching. The surface was therefore planed off until smooth bars with no surface flaws were obtained. But before doing this the precaution had not been neglected of determining that in the thin layer thus removed no difference in structure was observable, as compared with that of the bending bars. The manner in which the bending specimens were cut was shown in the accompanying sketch :—



= The outer rough surface which was removed (*a*).

= Material removed by planing or filing.

= Bending bars.

S = Longitudinal polished section for examination of the structure.

The notch in the bars on the left side of the figure was made on the side marked *o*; that in the bars on the right on the side marked *u*. It was true, however, that the objection raised by Mr. Saniter touched the weak point of bending tests with notched specimens; but provided the micro-structure of the material in the surface layer was proved by the aid of the microscope to be unchanged, this objection could hardly be sustained. Mr. Saniter asked why overheated steel, when reheated for a short time to 900°, should lose its brittleness, whereas an overheated steel in cooling to 900° remained brittle. The solution to this question demanded further experimenting and he preferred for the present to leave it unanswered. It was not impossible that a process of cooling conducted in a suitable manner might also counteract the brittleness.

actual or only apparent agreement with his own experiments, and these were used to form the subject of a "discussion" of considerable length; that was, they were contrasted with his (Mr. Ridsdale's) own published opinions. The object of this contrast he (Professor Heyn) had not been able to grasp. The second group of the author's experimental results, which were either opposed to Mr. Ridsdale's views or were new, were briefly characterised as "not correct." ("There was no deduction which could be accepted as correct for general purposes which was new," were Mr. Ridsdale's own words.) As characteristic of the infallibility of Mr. Ridsdale in thus lightly passing over the results of many years' careful research, he would only pick out the following sentence: "With regard to the relationship between the size of grain as seen under the microscope and the fracture grain, there was no need for the writer (Mr. Ridsdale) to enter controversial ground. Overheating gave clear indication by both methods which broadly corresponded." Occasionally the peculiarity of the method pursued by Mr. Ridsdale seemed to dawn upon him, since he felt it incumbent on him to emphasise that "all his remarks were offered in a perfectly courteous and friendly spirit." But in view of Mr. Ridsdale's curious conception of the correct mode of applying scientific criticism, it appeared to the author that nothing was to be gained by dealing further with his contribution to the discussion.

The claim of priority, put forward by Mr. Ridsdale to certain of the statements contained in the author's paper, was disposed of in the simplest way by saying that all right of priority in these matters belonged incontestably to Professor Tschernoff, of St. Petersburg, who as far back as 1868 had dealt with the primary phenomena of overheated steel in a far-seeing manner. It was with great pleasure that he was able to bear testimony to the excellent work of Professor Tschernoff, and he only regretted that he had not been previously acquainted with the contents of his article published in 1876 under the title of "The Structure of Steel. Remarks on the Manufacture of Steel and the Mode of Working it." * His (Professor Heyn's) work might be regarded as a continuation and extension of the laws then observed, and he was pleased that the groundwork laid down by Tschernoff,

* *Engineering*, vol. xxii. 1876, p. 11.

THE COMPRESSION OF STEEL BY WIRE-DRAWING DURING SOLIDIFICATION IN THE INGOT MOULD.

By H. HARMET (Saint-Etienne).

SECTION I.

The Necessity for Compression within the Ingot Mould to avoid the Effects due to Free Shrinkage.

The function of the engineer being to aspire to perfection in all that he undertakes, the steelmaker ought not to slacken in his efforts to learn and to obviate all defects which are met with continually during the process of manufacture of the metal until the moment when the finished product is obtained ready for use.

During these periods of the further process of manufacture, that is, during the first part of the life of the material, the metal undergoes three great successive transition stages which call for the most minute care on the part of those who have to conduct the operations. The first is the production of the liquid metal with the desired chemical composition without admixture of slag, without gases in solution, and without internal oxidations. It is within the furnace that the steelmaker perfects this first stage of the process.

The second is the transition from the liquid state to the solid state within the ingot mould, this being a crisis attended with many risks, since the metal is apt to contract defects which may appear impossible of remedy. It is to this period of the life of the metal that it is now desired to draw attention.

The third operation is the conversion of the raw solid material into the finished product. This last transition is less delicate than the two preceding ones, but nevertheless special care and treatment are requisite in order to attain the best physical constitution in each case. But the latter question may be dismissed for the moment, since it is proposed at present to limit the discussion to the phenomena which accompany the solidification of the metal and to the study of the precautions necessary to prevent these from becoming injurious.

the behaviour of the metal must be considered, if allowed to cool undisturbed.

(1) *Contraction.*—The form of the solid shell is determined from the time of the formation of the outer crust as regards its external dimensions. The greater part of the contraction has already taken place, but there still remains the internal liquid mass, of which the volume is greatly modified by shrinkage. Little by little, during cooling, this liquid mass becomes plastic and attaches itself progressively to the first shell, adding to its

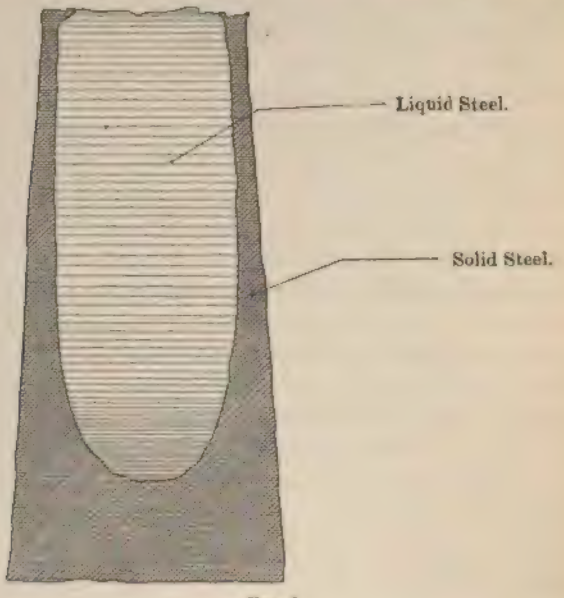
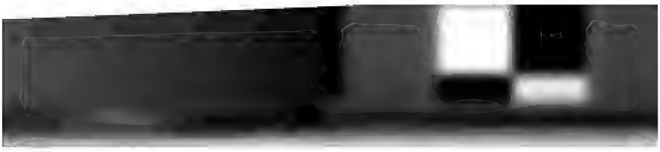
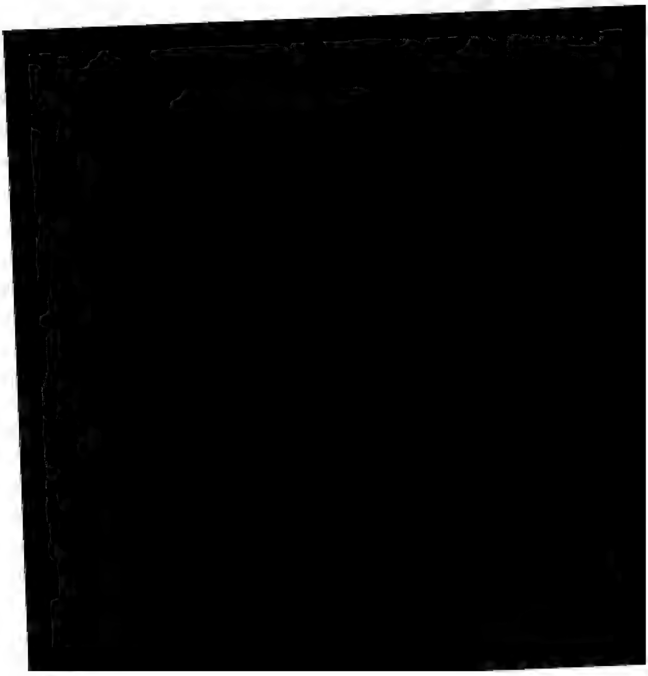


FIG. 1.

thickness. In the interior is left a hollow corresponding to the volume of the shrinkage.

The cold ingot, when divided through its vertical axis (see Fig. 1*a*), exposes to view a large cavity in the upper part due to the flow of metal, which, as long as it is liquid, continues to descend by its own weight to fill up the hollows left in the lower part due to shrinkage. Besides this a hollow space is formed in the centre itself after solidification, on account of the failure of the supply of liquid metal to fill the new cavities. This defect in the metal extends along the axis, visible to the





mould. For convenience it may be assumed that this amounts exactly to one metre; secondly, some moments after casting, the external shell of the ingot has already shrunk, being cooled by contact with the ingot mould, and immediately assumes the form and external dimensions which will be preserved up to the moment of stripping. Then, supposing that 20 millimetres per metre is the total shrinkage of the steel in passing from the liquid to the solid and cold state, and that the mean temperature at the moment of stripping is 700°, the shrinkage may be divided into two stages: that which takes place during the first phase of cooling from the liquid state to 700°, say 13 millimetres per metre, and that which occurs during the second phase from 700° to the temperature of the atmosphere, say 7 millimetres per metre.

Some moments after casting, therefore, the points A and B have separated from contact with the walls of the mould and have approached each other by the corresponding amount of shrinkage, say 13 millimetres, and the bar A B, which was originally one metre in length, is reduced to the length A_1 B_1, the length being now A B less 13 millimetres. This bar A_1 B_1 will now preserve its length without further alteration until the moment of stripping at 700°, since the points A_1 B_1 are definitely fixed, in the same manner as all other points in the shell of the ingot in question. How then will the still liquid mass of metal between points A_1 and B_1 behave in satisfying the conditions of the inevitable law of contraction until the moment of stripping? The metal contained between these points solidifies progressively, proceeding from either extremity. The contraction up to 1500°, the point of solidification, and the hollows which result are at first compensated for by the descent of the liquid metal from the upper layers, so long as the state of fluidity is such as to permit this. But as soon as the centre reaches the temperature of 1500°, the solidification becomes complete. The upper layers of liquid can no longer provide a supply, and the bar is subjected to the influence of contraction without the possibility of the cavities being filled up. Hence arises the necessity to assist the

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contraction in steel left undisturbed in the mould is productive of two kinds of serious defects: firstly, of pipe, cavities or porosities about the centre, while the metal is still liquid or in a plastic condition; and secondly, stresses, cracks, fissures, and even porosities throughout the whole mass which, nevertheless, to the naked eye appears compact and perfectly sound.

Crystallisation.—The steel in solidifying crystallises in the form of an interlacing dendritic structure upon the internal surface of the pipe, in regular needles on the external surface of the ingot, or in polyhedric grains within the central mass. These crystals have little cohesion between themselves, and when stresses due to contraction within the metal are set up, these meet with but low resistance and cracking occurs easily. The polyhedric crystals often form groups divided by planes analogous to cleavage planes, and the fracture of a large ingot exhibits facets which resemble those of spiegel. These constitute the weak points, which require subsequently to be strengthened by a forging process in order to obtain the necessary toughness in the finished product. This crystallisation of the steel is promoted by any step taken to delay the solidification, such as lining the upper part of the mould with refractory material, and also by the contraction of the ingot, which, when left to itself, separates from the cold walls of the mould.

Liquation.—The metalloids which enter into the composition of the steel have a tendency to separate from the iron by liquation. The carbon is the most mobile, being attracted in turn towards the more fluid parts, finally concentrating in those where solidification last takes place; that is, in the head of the ingot when left to cool undisturbed, and particularly if the solidification is delayed by the use of a refractory-lined mould.

Attempts have been made, when leaving the ingot to cool by itself, to prevent the formation of pipe by placing on the top of the ingot a cover of refractory material intended to preserve the heat and keep the steel liquid for a longer time in the upper part of the ingot, which serves as a reservoir to supply the lower part. All that is gained by this is, not the avoidance of pipe, which is proportionate to the shrinkage of the steel, the volume of the cavity remaining the same in any case, but the raising of

butable to the ingot mould. They can, moreover, be avoided by bottom-casting.

(2) *Static Compression.*—Before the introduction of compressing steel by wire-drawing, several attempts were made to compress the metal within the mould, but all depended in principle on applying a static pressure on the top of the ingot, instead of bringing it to bear, as in the wire-drawing method, upon the bottom, which, being of a dynamic kind, performs effective work. Compression with a static pressure acting on the top of the ingot is the principle involved in the Whitworth process.

In spite of the great force of the pressure applied in the latter process, the effect of it extends only to the exterior of the ingot, which in cooling rapidly forms a crust with the rigidity of a column, and thus arrests the force applied and protects the whole of the central part against this pressure from above. The ingot is, moreover, depressed in the centre, and though the pipe has not exactly the form which it would have had if left to cool freely, yet it still affects the centre throughout a great part of its height. The method may answer for hollow pieces which have a raised centre, but is ineffective for solid bodies such as armour plates.

The central mass of the ingot being moreover relieved from compression, as is proved by the presence of cavities in the centre, the fluid steel is left to itself and in consequence becomes affected by the injurious influence of liquation and coarse crystallisation. The effect of this compression therefore accentuates rather than alleviates the strains, cracks, and internal fissures which are observable in steel left to cool undisturbed. Thus the line A_1 B_1 before mentioned becomes after compression A_2 B_2, greater than A_1 B_1, or even A B. A swelling up of the metal occurs, which is continually intensified, the pressure meanwhile forcing the points A_2 B_2 into contact with the walls of the mould, which latter also expand on account of the heat. When the feeding process from the upper layers has ceased, the mass of compressed metal between the points A_2 and B_2 begins to contract, and the stresses and cracks will be more pronounced even than when cooling takes place alone. The extremities of the imaginary line continue to move apart in proportion as the ingot mould heats up, and the metal about the line must therefore contract by an amount equal to the increased distance apart

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and the action of the compression is similar to a forging operation. In order to combat efficaciously the effect of shrinkage, the compression of steel by wire-drawing must therefore be applied to the whole surface of the ingot, restricting or diminishing its volume by closing inwards upon the central mass as shrinking proceeds. This entails the performance of work, work which constitutes the underlying principle of the process, and the value of which is proportionate to the total contraction of the mass upon which it acts. The amount of contraction per unit of volume or of weight is constant for one kind of steel of definite character. But it varies in the case of different kinds of steel. The work necessary to counteract the effect of this contraction per unit of weight will consequently be a constant amount for each kind of steel. Starting from this point, the work necessary to compress by wire-drawing any kind of ingot will be proportionate to the weight of the ingot.

With regard to the defects of the second category, the liquation and formation of coarse crystals with cleavages are due to retardation in cooling. It is impossible to overcome these defects completely, since instantaneous solidification is out of the question. But for the following reasons their occurrence may be sensibly diminished by compression by wire-drawing, introduced primarily to counteract contraction :—

(*a*) The ingot mould in which compression is carried out not only consists of a great mass of metal which rapidly absorbs a quantity of heat, but it is kept in constant contact with the metal to be cooled by the gradual advancement of the ingot under pressure from below.

(*b*) In a liquid body which contracts or undergoes reduction of volume in passing into the solid state, pressure hastens the transition. This results in shortening the time, and at the same time a diminution in the crystallisation and of the liquation is effected.

(*c*) The molecular movement, which owing to pressure takes place throughout the mass, also tends to effect a diminution in the crystallisation and of the liquation.

(*d*) Finally, another circumstance which in general tends to hasten the cooling and diminish crystallisation and liquation (contrary to the effect of a refractory-lined mould) is the

to accumulate in the upper part of the ingot is lessened. This is also effected by forcing the metal into intimate contact with the thick ingot mould, and especially by causing it to advance gradually towards the cold parts of the walls.

Such is the operation of compression by wire-drawing, which, by leaving exposed the upper portion of the ingot and applying pressure to the base, causes it to rise in the conical mould as though being forced through a draw-plate. The solid crust shown in Fig. 1 doubles inwards, driving the internal metal upwards, the action being similar to that of the pressure of the hand upon a rubber ball, and by this means the formation of cavities are avoided, which occur if the metal is left to contract freely. The pressure upon the base, or the rate of advancement within the mould, is so controlled as to keep the shell constantly full without overflowing. The speed is regulated according to the rate of contraction, exceeding the latter slightly, in order to maintain every portion of the ingot under a state of continuous pressure, but a tensile stress never occurs in any portion. The conical form, which is essential for producing lateral stricture in proportion as the ingot advances, increases the power of the press by producing a wedge-like action.

This compression by wire-drawing being applied to the metal immediately after casting, and placing the whole mass under pressure without causing any tensile strain, entirely prevents the formation of internal cracks from the first moment it is brought into action. It also preserves the absolute solidity of the ingot without pipe or cavities about the centre, produces a fine crystallisation without cleavage planes, greatly reduces liquation, and generally improves the physical properties owing to the effect being similar to that of forging. Finally, on taking a vertical section through the axis, the compressed ingot presents the shape and appearance shown in Fig. 2, Plate III., whereas without compression the same metal would have resembled the ingot shown in Fig. 3, Plate III.

In order to effect the compression by wire-drawing, the mechanical arrangement which appears best adapted is that represented in Plate IV. These machines are now actually in operation at the steelworks of Saint-Etienne, and comprise the following :—

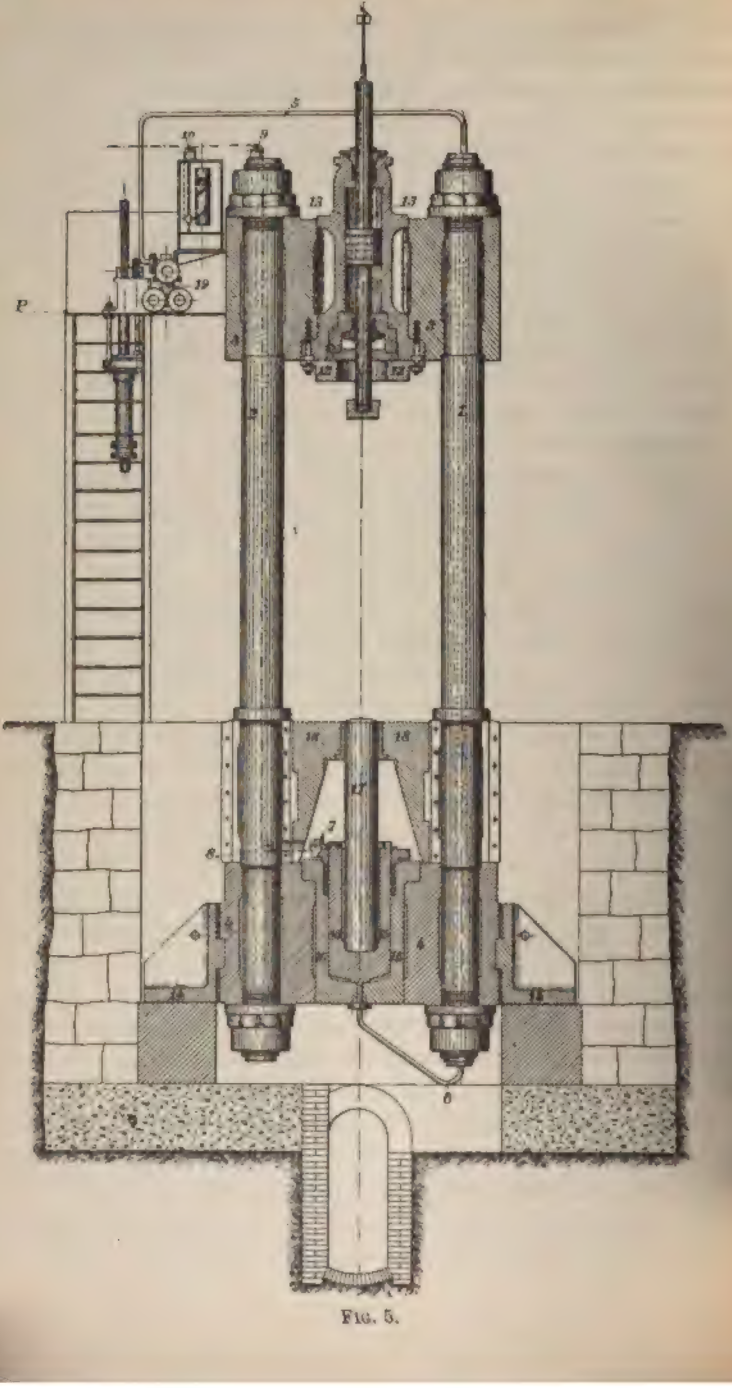
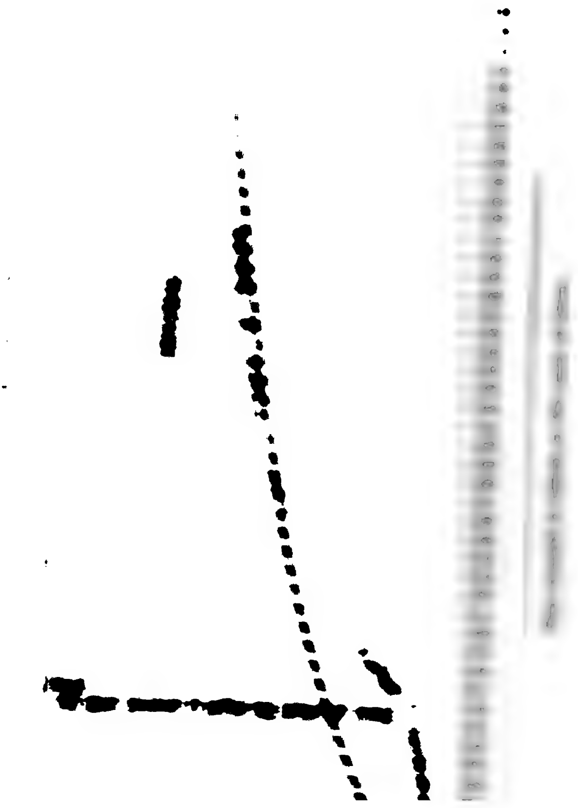


FIG. 5.

PLATE IV.

Fig. 1.—[illegible]



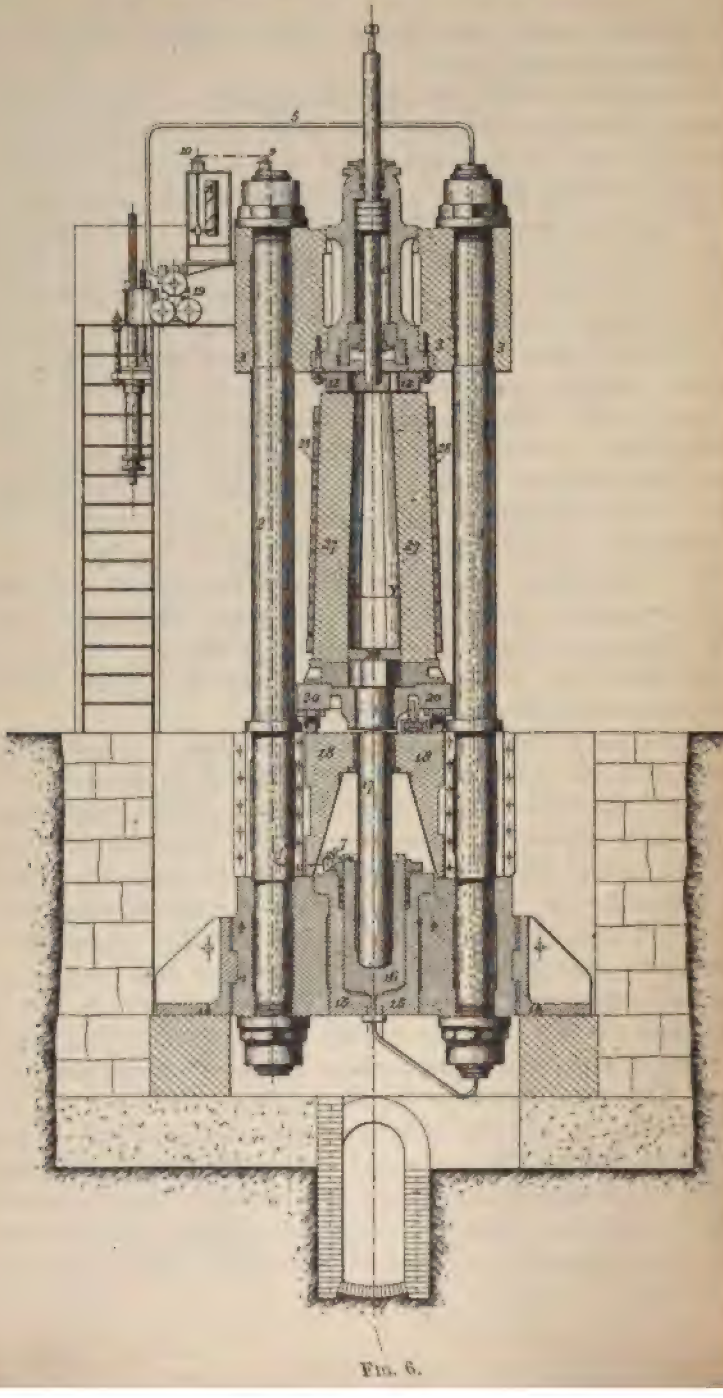


Fig. 6.

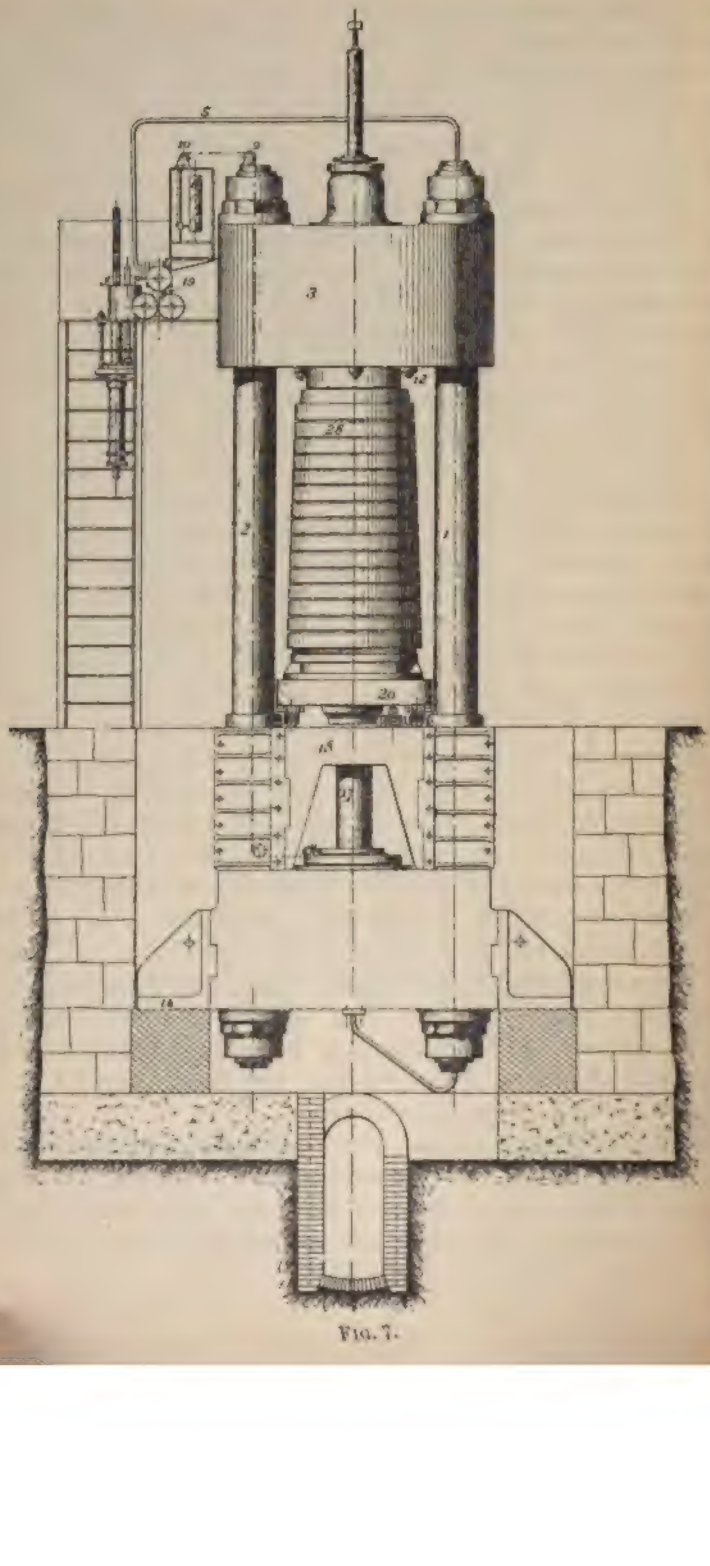


Fig. 7.

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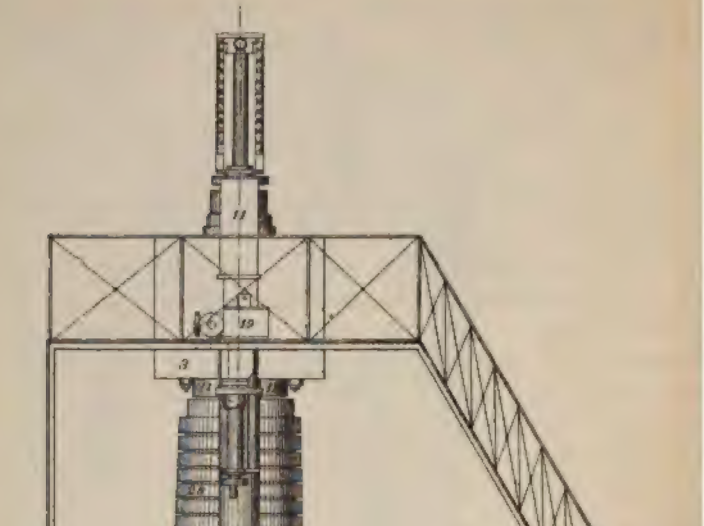

FIG. 8.

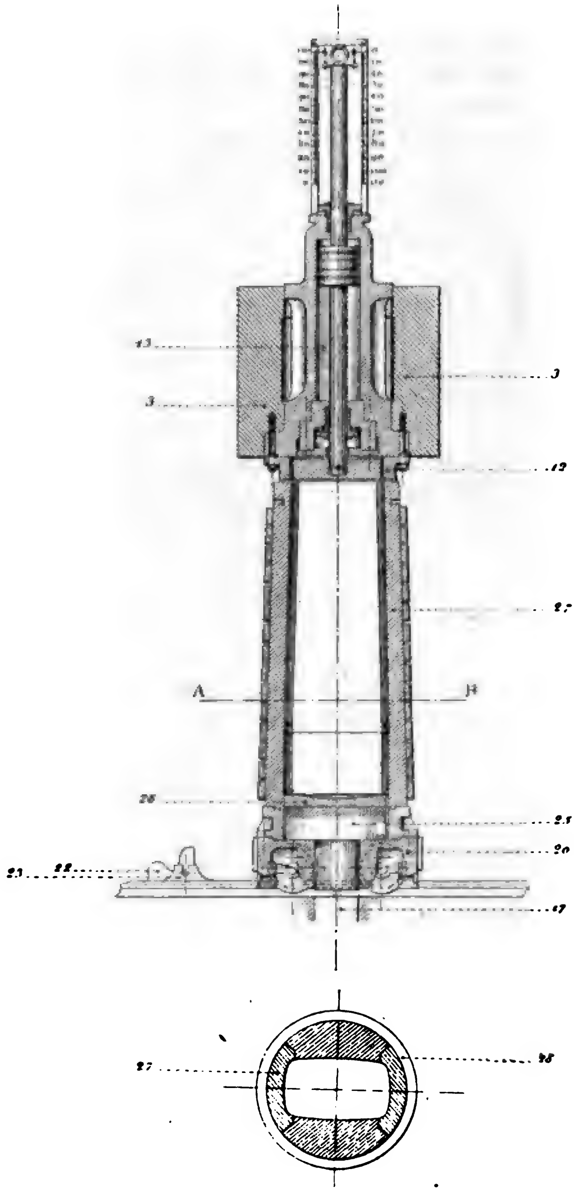

Fig. 9.

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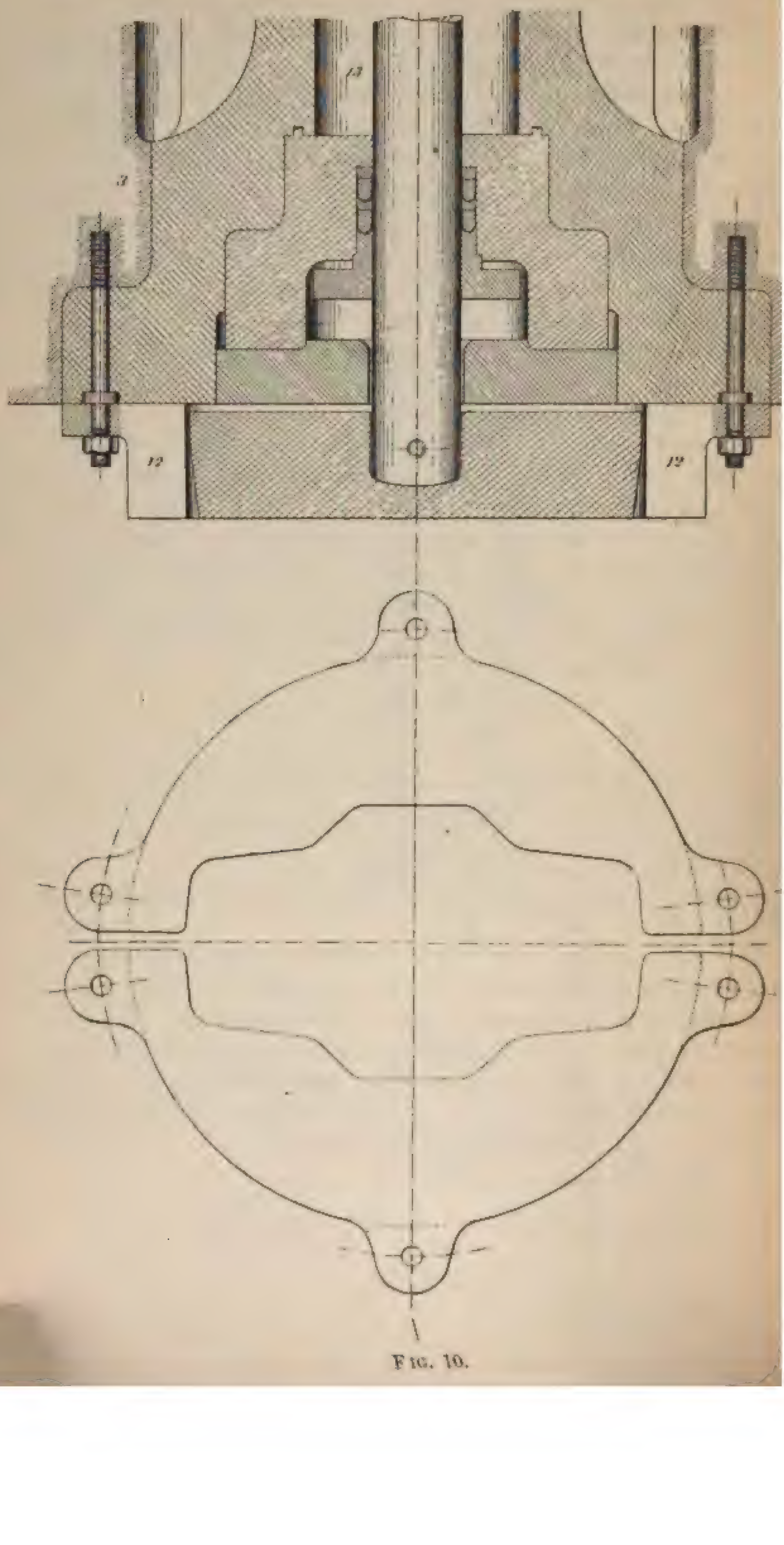
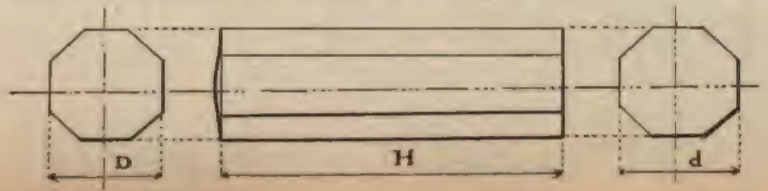


FIG. 10.

		Type No. 1	Type No. 2	Type No. 3	Type No. 4	Type No. 5	Type No. 6	Type No 7	Type No. 8	Type No. 9	Type No. 10
Nominal capacity of the press		75 tons	100 tons	200 tons	300 tons	400 tons	500 tons	750 tons	1,000 tons	5,000 tons	10,000 tons
Approximate particulars of presses.	Pressure of water per square centimetre	450 kg.	450 kg.	450 kg.	450 kg.	450 kg.	450 kg.	450 kg.	450 kg.	450 kg.	450 kg.
	Diameter of compressor cylinder	150 mm.	175 mm.	250 mm.	300 mm.	350 mm.	400 mm.	475 mm.	550 mm.	1,200 mm.	1,700 mm.
	Stroke of ram	170 ,,	200 ,,	285 ,,	345 ,,	400 ,,	445 ,,	545 ,,	635 ,,	1,420 ,,	2 met.
	Approximate weight of press	3,000 kg.	7,500 kg.	15,000 kg.	30,000 kg.	40,000 kg.	50,000 kg.	75,000 kg.	100,000 kg.	500,000 kg.	800,000 kg.
Particulars of ingots compressed during the first phase and stripped when at red heat.	Maximum area of ingot at the base	250 cm.²	330 cm.²	660 cm.²	1,000 cm.²	1,330 cm.²	1,660 cm.²	2,500 cm.²	3,330 cm.²	16,660 cm.²	33,330 cm.²
	Octagonal ingot corresponding to the maximum area of base: D	170 mm.	200 mm.	285 mm.	345 mm.	400 mm.	445 mm.	545 mm.	635 mm.	1,420 mm.	2 met.
	d	125 ,,	150 ,,	210 ,,	255 ,,	295 ,,	330 ,,	405 ,,	470 ,,	1·050 m.	1·480 m.
	H	550 ,,	650 ,,	925 ,,	1·120 m.	1·300 m.	1·450 m.	1·770 m.	2·050 m.	4·600 ,,	6·500 ,,
	weight	75 kg.	125 kg.	350 kg.	630 kg.	980 kg.	1,350 kg.	2,480 kg.	4,000 kg.	44,000 kg.	120,000 kg.
	Minimum area possible at the base of ingot	75 cm.²	100 cm.²	180 cm.²	260 cm.²	390 cm.²	500 cm.²	720 cm.²	880 cm.²	3,900 cm.²	8,000 cm.²
	Pressure per cm.² on the base of ingot	300 kg.	300 kg.	300 kg.	300 kg.	300 kg.	300 kg.	300 kg.	300 kg.	300 kg.	300 kg.
	Total lateral pressure	300 tons	400 tons	800 tons	1,200 tons	1,600 tons	2,000 tons	3,000 tons	4,000 tons	20,000 tons	40,000 tons
	Lateral area	2,820 cm.²	3,920 cm.²	7,950 cm.²	11,600 cm.²	15,600 cm.²	19,300 cm.²	28,750 cm.²	39,400 cm.²	196,000 cm.²	392,500 cm.²
	Pressure per cm.² on the lateral area	106 kg.	103 kg.	101 kg.	103 kg.	102 kg.	104 kg.	104 kg.	102 kg.	102 kg.	102 kg.
	Length of cylindrical portion of the mould	135 mm.	160 mm.	225 mm.	275 mm.	320 mm.	355 mm.	435 mm.	510 mm.	1·130 m.	1·600 m.



It is interesting to note here that the ingot No. 24 was cast in a very thick mould, with a consequent strong cooling effect, a circumstance which improves the quality of the metal, but is of

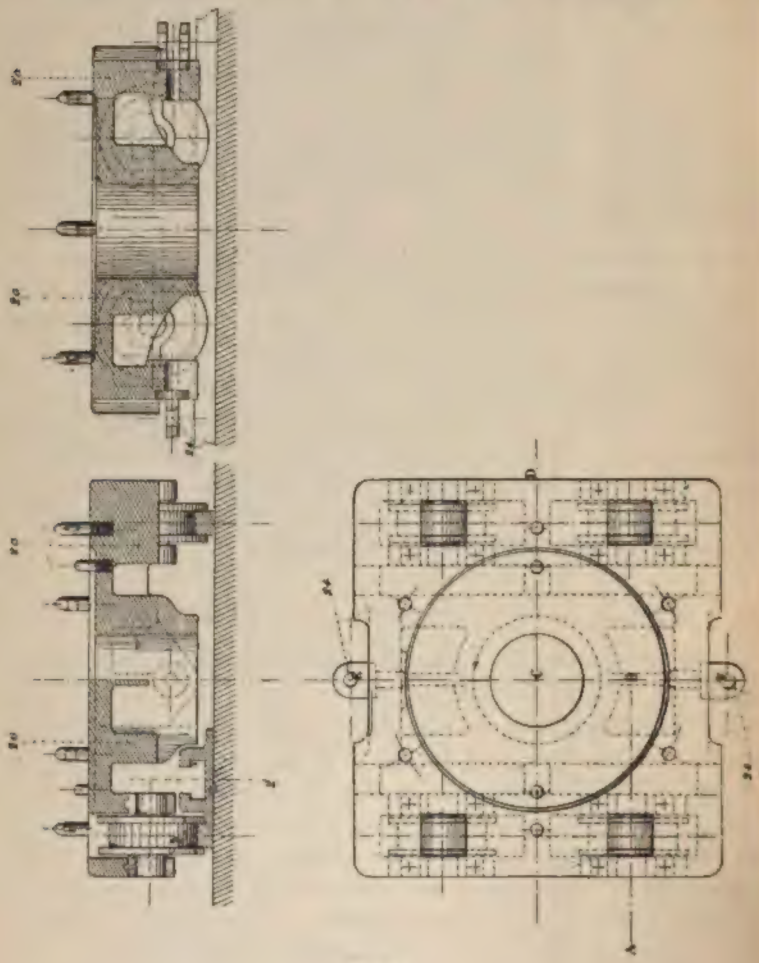


Fig. 11.

injurious effect as regards pipe. It showed a central cavity of remarkable extent towards the base, which is simply the result of the thickness of the mould. This ingot is an example of what is actually obtained in many cases.

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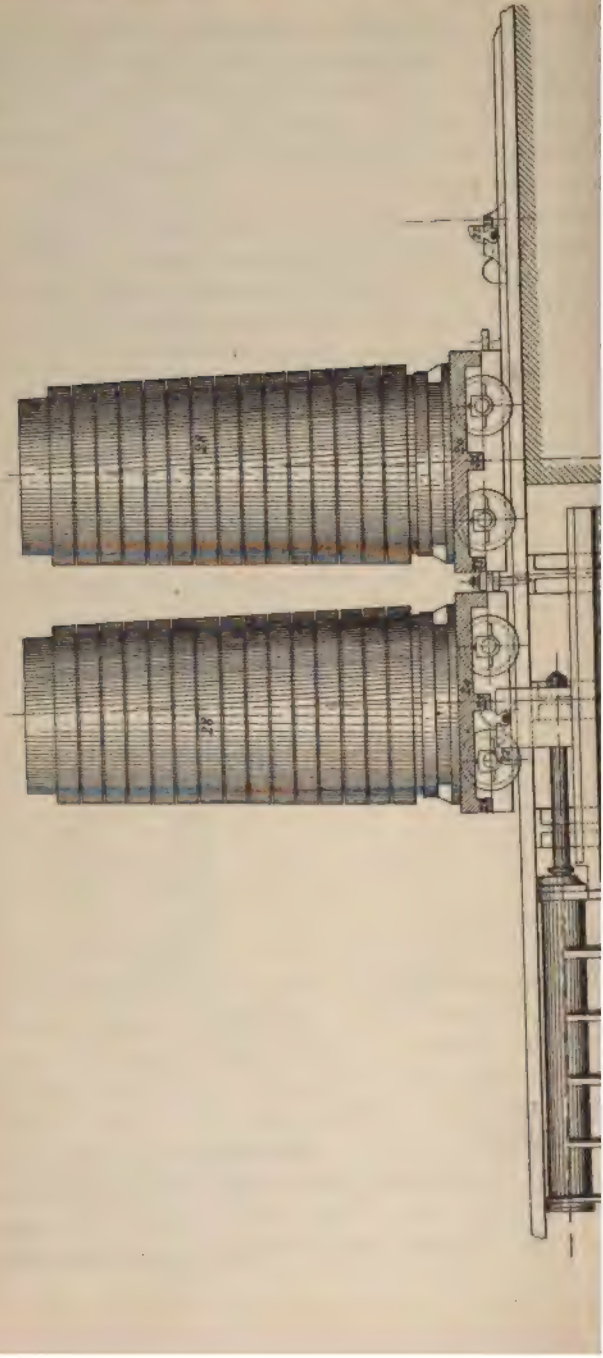

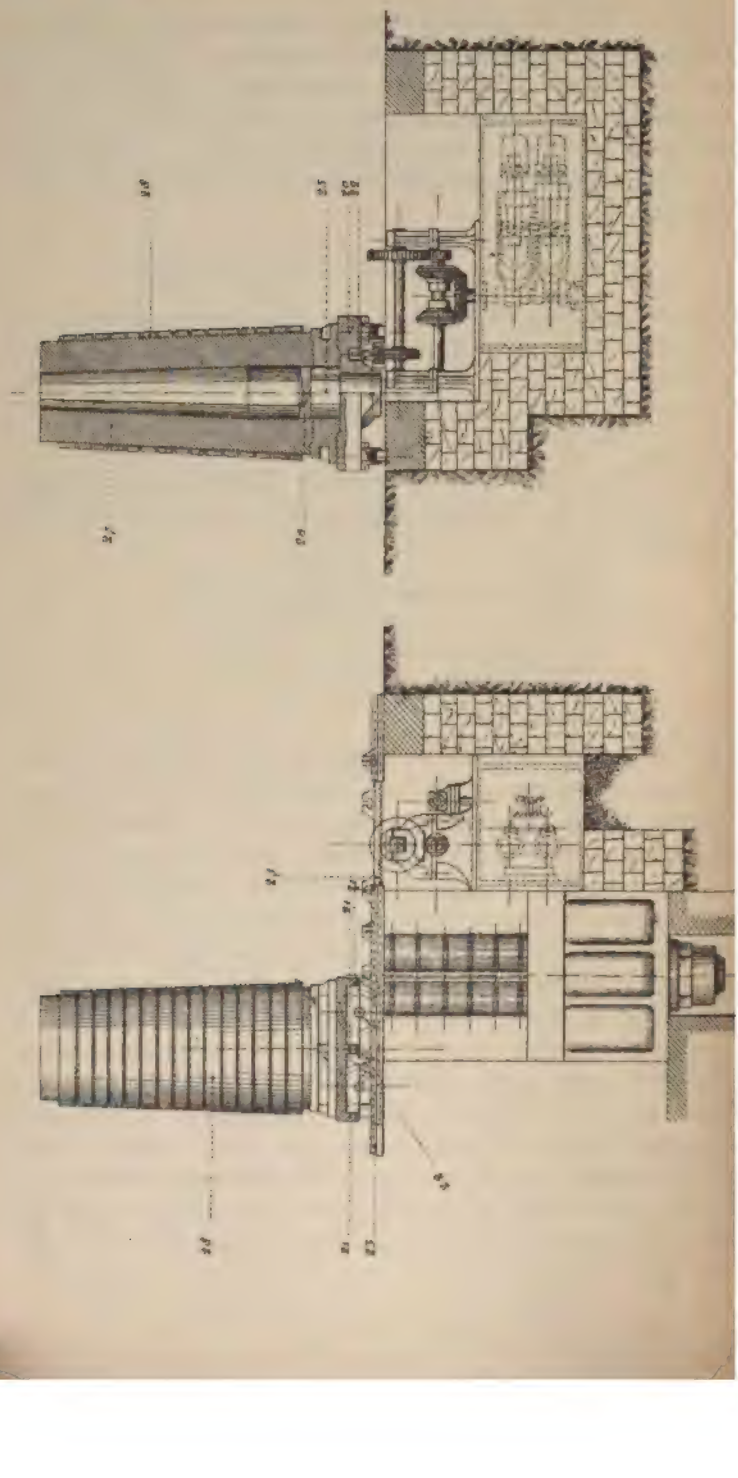

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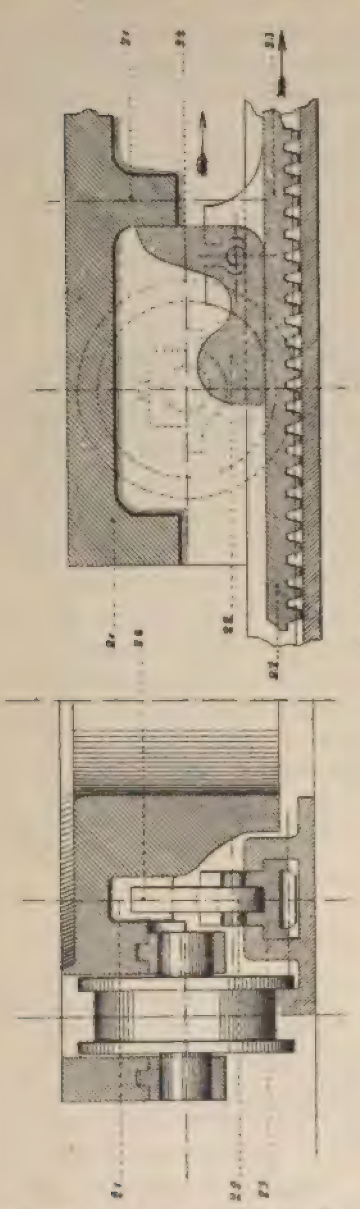
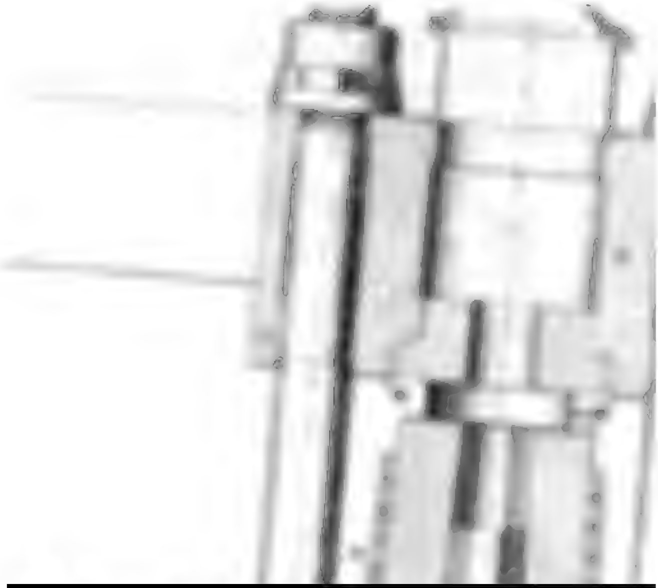


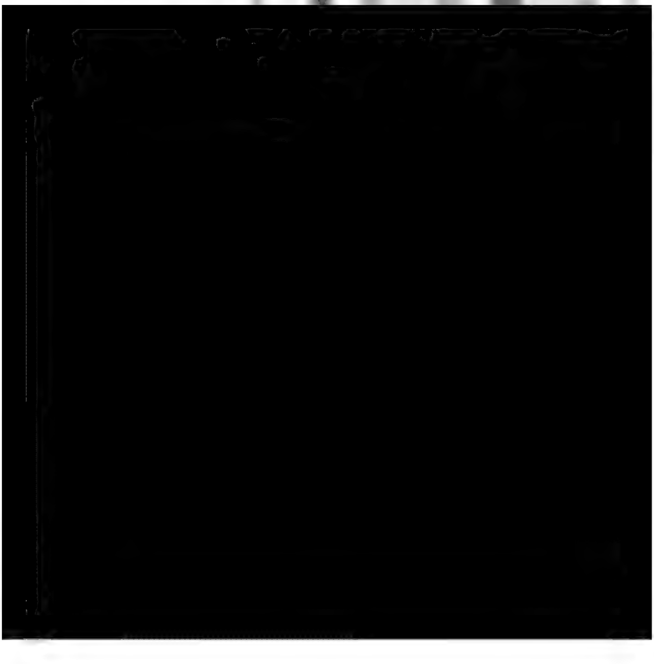
FIG. 14.

then drilled, the core part being cut out in the form of a round bar of 50 millimetres in diameter. The compressed ingot was in the rough state, having neither been forged nor rolled, and was entire. A similar round bar was drilled out of the core of this latter, and the fractures of these two round bars were shown. Dark patches appeared on the two upper specimens from the compressed ingot, but these were in reality merely shadows, and the two fractures did not reveal any cavity. In the case of the uncompressed ingot, however, the first seven pieces, reckoning from the upper end of the ingot, were defective in the centre, in spite of having had cropped off a piece equal to 28 per cent. of the weight.

(5) *Superiority of the Sound Metal even in the Core of the Ingot.*

A compact metal, free from defects in the very core, is undeniably the best for every kind of manufacture, since forging or rolling always has a tendency to strain the core of the metal, a tendency which is aggravated by the defects already existing. Thus all armour plates show about the centre of their thickness a plane of fatigue, which becomes a plane of





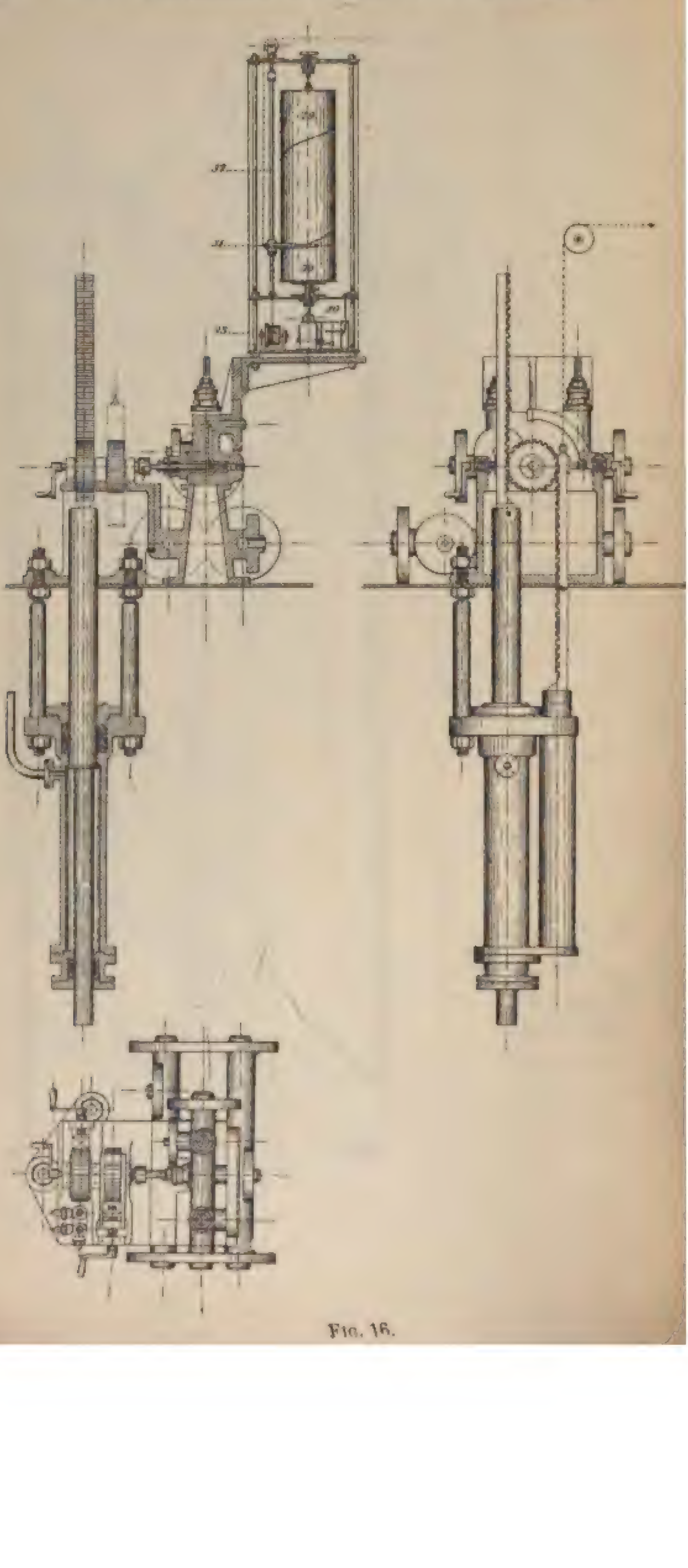


Fig. 16.

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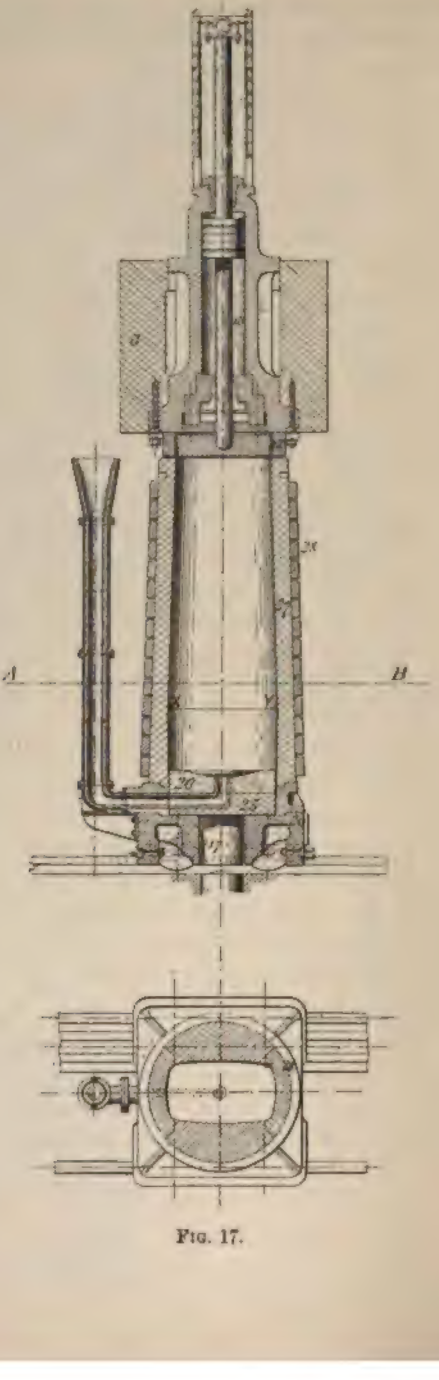

FIG. 17.

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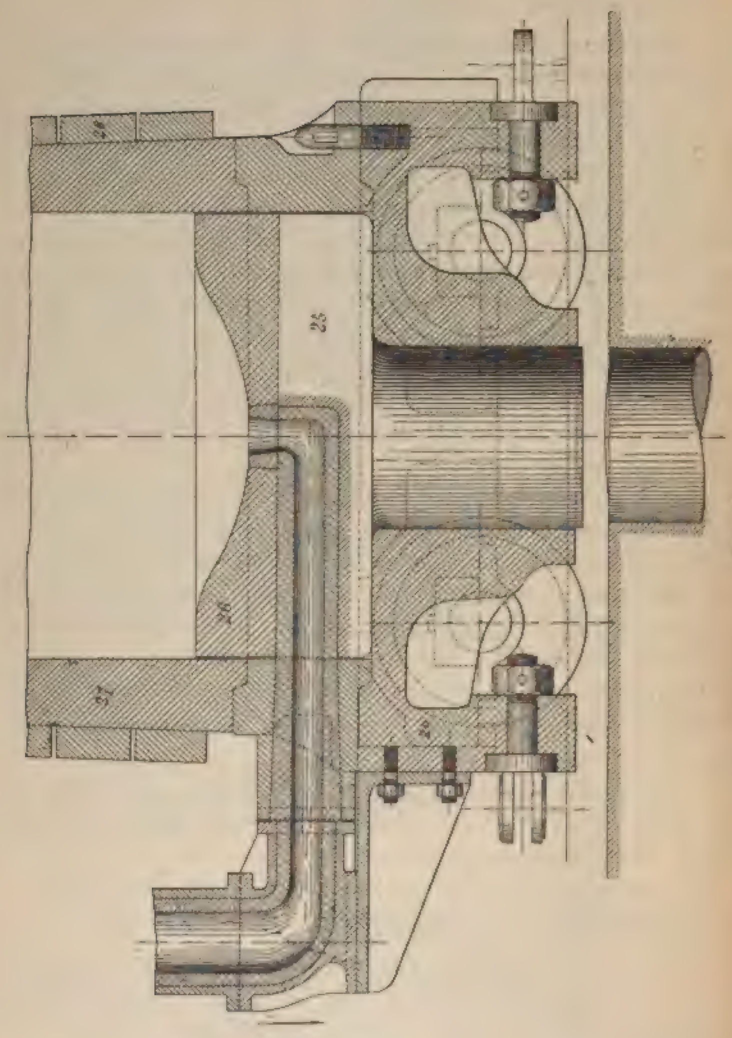

Fig. 18.

TABLE II.—TESTS ON ROUGH INGOTS.

Specimens cut from the Cross Section of a Slab containing the Vertical Axis of each Ingot.

(Heat No. 32,331.)

COMPRESSED INGOT, THE WASTE BEING 5 PER CENT. OF THE METAL.

TENSILE TESTS.

Marks.		Dimensions. Before Rupture.	Dimensions. After Rupture.	Areas. Before Rupture.	Areas. After Rupture.	Elastic Limit per Mm².	Load producing Rupture. Total.	Load producing Rupture. Kilogs. per Mm².	Elongation after Rupture. In a Length of 100 Mm.	Elongation after Rupture. Reduction of Area, $\frac{S-S'}{S'} \times 100$.	Fractures. [See p. 218.]	Remarks.
		Mm.	Mm.	Mm.	Mm.		Kilogs.		Per Cent.	Per Cent.		
Bottom	T 1	13·8	13·0	149·6	132·7	71·6	11,000	73·5	5·0	12·7	BK	
	T 2	13·8	12·6	149·6	124·7	72·9	12,000	80·2	7·0	20·0	BK	
	T 3	13·8	11·5	149·6	103·9	69·6	12,300	82·3	11·0	44·0	B	
Middle	T 1	13·8	12·8	149·6	128·7	71·6	12,600	84·3	7·0	16·2	BK	
	T 2	13·9	12·7	151·7	126·7	71·2	12,400	81·7	6·0	19·8	K	
	T 3	13·9	12·8	151·7	128·7	71·2	12,600	83·1	7·2	17·9	BF	
Top	T 1	13·7	13·3	147·4	134·8	70·5	10,400	70·5	3·0	6·1	BD	
	T 2	13·9	13·2	151·7	136·9	75·1	12,500	82·4	7·0	10·9	B	
	T 3	13·8	11·5	149·6	103·9	74·9	12,300	82·3	10·5	44·0	BF	

IMPACT TESTS.—*Bars*=20 × 20 *mm. Weight of Drop-hammer*=18 *kilogs.*

Bottom	C 1	Deflected 33 mm. at the 20th blow from height of 1·10 m. Broken in the press at an angle of 92°.
	C 2	Broken at the 8th blow. Angle 148°.
	C 3	Deflected 31 mm. at the 20th blow from height of 1·10 m. Broken in the press at an angle of 90°.
Middle	C 1	Broken at the 20th blow. Angle 113°.
	C 2	Deflected 32 mm. at the 20th blow from height of 1·10 m. Broken in the press at an angle of 98°.
	C 3	Broken at the 13th blow. Angle 135°.
	C 1	Broken at the 13th blow. Angle 150°.

TABLE II.—*Continued.*

INGOT CAST IN MOULD WITHOUT LINING, THE WASTE BEING 28 PER CENT. OF THE METAL.

TENSILE TESTS.

Marks.		Dimensions. Before Rupture.	Dimensions. After Rupture.	Areas. Before Rupture.	Areas. After Rupture.	Elastic Limit per Mm^2.	Load producing Rupture. Total.	Load producing Rupture. Kilogs. per Mm^2.	Elongation after Rupture. In a Length of 100 Mm.	Elongation after Rupture. Reduction of Area, $\frac{S-S'}{S'} \times 100$.	Fractures.	Remarks.
		Mm.	Mm.	Mm.	Mm.		Kilogs.		Per Cent.	Per Cent.		
Bottom	T 1	13·8	12·8	149·6	128·7	72·9	12,200	81·6	8·0	16·2	D	
	T 2	13·9	13·0	151·7	132·7	66·6	10,700	70·5	5·0	14·3	KD	
	T 3	13·9	13·4	151·7	141·1	68·5	11,000	72·5	6·5	7·6	KD	
Middle	T 1	13·9	13·2	151·7	136·9	69·9	11,0.0	72·5	4·5	10·9	KD	
	T 2	13·8	13·0	149·6	132·7	61·5	9,200	61·5	2·0	12·7	KD	Blowholes.
	T 3	13·8	13·3	149·6	139·0	62·6	9,500	62·6	2·3	7·7	KD	,,
Top	T 1	...	...	Defective Specimen.			Results, Nil.				...	
	T 2	...	...	,,			,,	,,			...	
	T 3	...	...	,,			,,	,,			...	

IMPACT TESTS.—*Bars*=20×20 *mm.* *Weight of Drop-hammer*=18 *kilogs.*

Marks.		
Bottom	C 1	Deflected 32 mm. at the 20th blow from height of 1·10 m. Broken in the press at an angle of 79°.
	C 2	Broken at the 3rd blow from a height of 1·10 m. Angle 160°.
	C 3	,, 5th ,, ,, ,, 152°.
Middle	C 1	,, 8th ,, ,, ,, 141°.
	C 2	,, 6th ,, ,, ,, 148°.
	C 3	,, 5th ,, ,, ,, 154°.

Table III.—*Continued.*

BLOOM FROM INGOT CAST IN REFRACTORY-LINED MOULD, THE WASTE BEING 28 PER CENT. OF THE METAL.

Tensile Tests.

Marks.		Dimensions.		Areas.		Elastic Limit per Mm².	Load producing Rupture.		Elongation after Rupture.		Fractures.	Remarks.
		Before Rupture.	After Rupture.	Before Rupture.	After Rupture.		Total.	Kilogs. per Mm².	In a Length of 100 Mm.	Reduction of Area, $\frac{S-S'}{S'} \times 100$.		
		Mm.	Mm.	Mm.	Mm.		Kilogs.		Per Cent.	Per Cent.		
Bottom	T 1	13·9	11·6	151·7	105·7	39·5	9,700	63·9	16·5	43·6	B	
	T 2	13·8	10·7	149·6	89·9	60·2	11,100	74·2	12·5	66·3	B	
	T 3	13·7	10·5	147·4	86·6	51·5	10,300	69·8	13·0	70·2	F	
Middle	T 1	13·9	11·0	151·7	95·0	60·0	10,900	71·8	12·2	59·7	F	
	T 2	13·8	12·5	149·6	122·7	59·5	11,000	73·5	10·0	21·9	BD	
	T 3	13·7	12·4	147·4	120·8	59·7	11,200	76·0	7·0	22·1	BD	
Top	T 1	13·8	13·0	149·6	132·7	...	9,200	61·5	2·0	12·7	D	
	T 2	13·9	13·6	151·7	145·3	...	7,000	46·1	1·0	4·5	D	
	T 3	13·8	...	149·6	...		Defective Specimen. Results, Nil.					

Impact Tests.—*Bars*=20 × 20 *mm.* *Weight of Drop-hammer*=18 *kilogs.*

Bottom	C 1	Deflection=31 mm.	at the 20th blow	from height of	1·10 m.	Broken in the press	at an angle	of 0°.
	C 2	29	"	"	"	"	"	45°.
	C 3	34	"	"	"	"	"	25°.
Middle	C 1	31	"	"	"	"	"	28°.
	C 2	28	"	"	"	"	"	30°.
	C 3	32	"	"	"	"	"	88°.

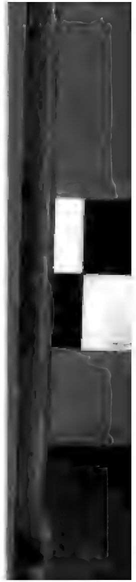

TABLE IV.—TESTS ON FORGED BLOOMS SUBJECTED TO FOUR WORKINGS.

Test Specimens cut from the Cross Section of a Slab containing the Vertical Axis of each Bloom.

(Charge No. 32.359.

BLOOM FROM COMPRESSED INGOT THE WASTE BEING 5 PER CENT OF THE METAL.

TENSILE TESTS.

Marks.		Dimensions.		Areas.		Elastic Limit per Mm².	Load producing Rupture.		Elongation after Rupture.		Fractures.	Remarks.
		Before Rupture.	After Rupture.	Before Rupture.	After Rupture.		Total.	Kilogs. per Mm².	In a Length of 100 Mm.	Reduction of Area, $\frac{S-S'}{S'} \times 100$.		
		Mm.	Mm.	Mm.	Mm.		Kilogs.		Per Cent.	Per Cent.		
Bottom	T 1	13·7	11·4	147·4	102·1	68·5	12,000	81·4	10·8	44·4	B	
	T 2	13·8	11·2	149·6	98·5	66·2	12,000	80·2	11·0	51·8	B	
	T 3	13·8	10·9	149·6	93·3	66·2	12,000	80·2	11·2	60·3	B	
Middle	T 1	13·8	10·7	149·6	89·9	68·9	12,400	83·0	12·0	66·3	B	
	T 2	13·8	11·1	149·6	96·8	63·5	11,800	78·9	11·0	54·6	B	
	T 3	13·8	12·1	149·6	115·0	68·3	12,000	80·2	9·0	30·1	B	
Top	T 1	13·9	12·0	151·7	113·1	65·9	12,800	84·4	9·0	34·2	BD	
	T 2	13·9	11·4	151·7	102·1	69·9	12.700	83·7	9·5	48·7	B	
	T 3	13·9	11·5	151·7	103·9	69·2	12,400	81·7	5·5	46·1	B	

IMPACT TESTS.—*Bars*=20 × 20 *mm. Weight of Drop-hammer*=18 *kilogs.*

Marks.		
Bottom C 1	Deflection=30 mm. at the 20th blow from height of 1·10 m. Broken in the press at an angle of	70°.
C 2	32 ,, ,, ,, ,, ,,	91°.
C 3	36 ,, ,, ,, ,, ,,	35°.
Middle C 1	32 ,, ,, ,, ,, ,,	48°.
C 2	31 ,, ,, ,, ,, ,,	49°.
C 3	35 ,, ,, ,, ,, ,,	85°.

TABLE IV.—*Continued.*

BLOOM FROM INGOT CAST IN MOULD WITHOUT LINING, THE WASTE BEING 28 PER CENT. OF THE METAL.

TENSILE TESTS.

Marks.		Dimensions. Before Rupture.	Dimensions. After Rupture.	Areas. Before Rupture.	Areas. After Rupture.	Elastic Limit per Mm².	Load producing Rupture. Total.	Load producing Rupture. Kilogs. per Mm².	Elongation after Rupture. In a Length of 100 Mm.	Elongation after Rupture. Reduction of Area, $\frac{S-S'}{S'} \times 100$.	Fractures.	Remarks.
		Mm.	Mm.	Mm.	Mm.		Kilogs.		Per Cent.	Per Cent.		
Bottom	T 1	13·8	11·2	149·6	98·5	52·9	10,600	70·9	11·0	51·8	F	
	T 2	13·8	...	149·6	...	66·2	11,500	76·9	7·0	...	B	
	T 3	13·8	13·0	149·6	132·7	40·1	9,300	62·2	10·5	12·7	G	
Middle	T 1	13·8	9·8	149·6	75·4	46·8	9,600	64·2	17·0	98·3	B	
	T 2	13·8	9·7	149·6	73·9	39·4	9,700	64·8	17·0	102·4	B	
	T 3	13·8	...	149·6	...		Defective Specimen.	Results, Nil.				
Top	T 1	13·9	..	151·7	...		,,	,,	,,			
	T 2	13·8	...	149·6	...		,,	,,	,,			
	T 3	13·8	...	149·6	...		,,	,,	,,			

IMPACT TESTS.—*Bars*=20 × 20 *mm.* *Weight of Drop-hammer*=18 *kilogs.*

Bottom	C 1	Deflection=31 mm. at the 20th blow from height of 1·10 m. Broken in the press at an angle of 80°.
	C 2	40 ,, ,, ,, ,, ,, 0°.
	C 3	34 ,, ,, ,, ,, ,, 44°.
Middle	C 1	37 ,, ,, ,, ,, ,, 0°.
	C 2	38 ,, ,, ,, Doubled close in the press without cracking.
	C 3	40 ,, ,, ,, Broken in the press at an angle of 69°.
	C 1	34

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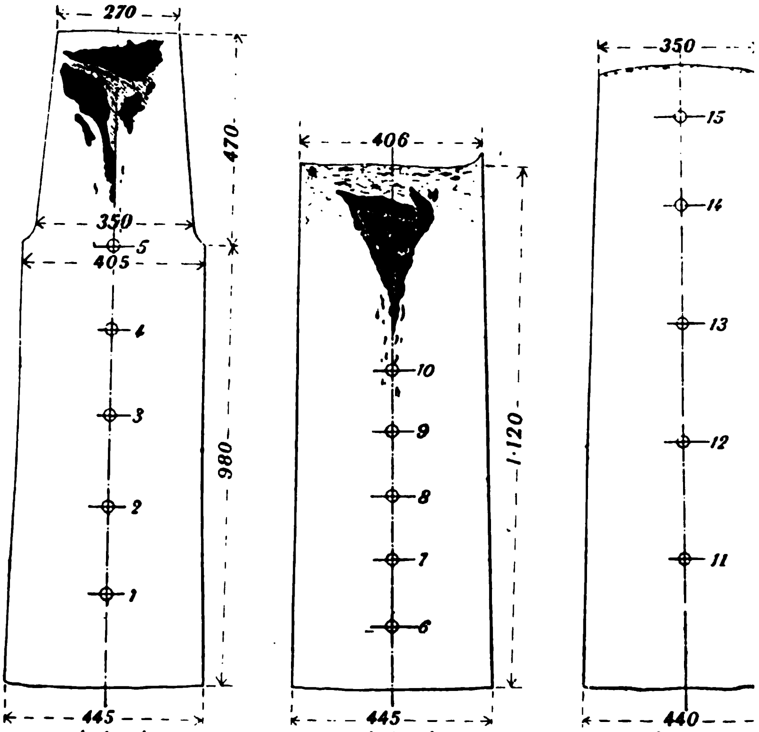
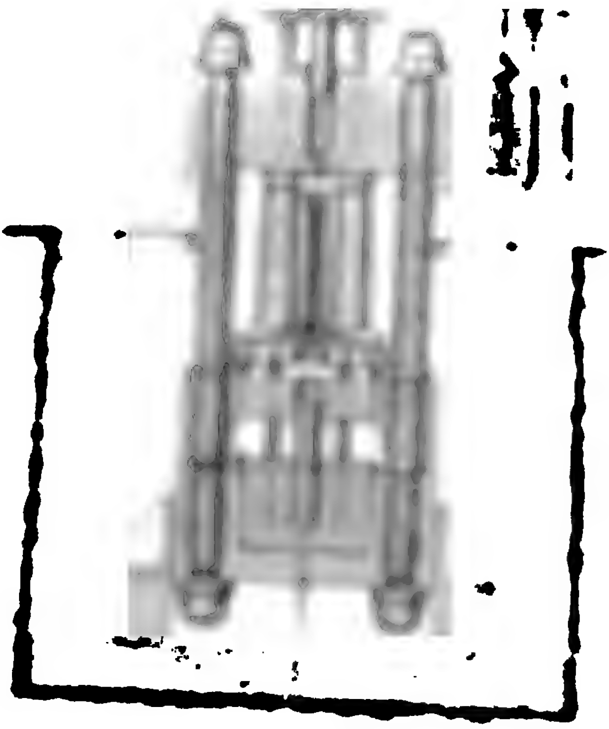
Table V.—Tests of Rough Ingots.

(Analyses taken along the centre.)

Steel cast in lined mould. Weight=1335 kg.	Steel cast in plain mould. Weight=1210 kg.	Compressed s Weight=134(



	Per Cent.		Per Cent.		Per Cer
1	C=0·41, S=0·007, P=0·022	6	C=0·40, S=0·008, P=0·023	11	C=0·40, S=0·008, P=0·023
2	C=0·40, S=0·007, P=0·023	7	C=0·40, S=0·007, P=0·023	12	C=0·41, S=0·008, P=0·024
3	C=0·40, S=0·008, P=0·023	8	C=0·41, S=0·007, P=0·024	13	C=0·42, S=0·009, P=0·023
4	C=0·43, S=0·010, P=0·024	9	C=0·45, S=0·010, P=0·024	14	C=0·42, S=0·009, P=0·025
5	C=0·46, S=0·013, P=0·027	10	C=0·45, S=0·010, P=0·025	15	C=0·41, S=0·009, P=0·023



Analyses.

5-*ton Ingot.—Charge No.* 33,630. (*Ingot No.* 31.)

No. of Samples taken.	C.	Mn.	Si.	S.	P.
1	0·392	0·630	0·290	0·035	0·052
2	0·414	0·640	0·280	0·037	0·055
3	0·419	0·653	0·280	0·040	0·056
4	0·423	0·653	0·290	0·042	0·055
5	0·396	0·648	0·280	0·034	0·051
6	0·410	0·635	0·280	0·034	0·050
7	0·410	0·630	0·280	0·036	0·049
8	0·387	0·635	0·280	0·034	0·051
9	0·396	0·635	0·280	0·035	0·051

5-*ton Ingot.—Charge No.* 33,676. (*Ingot No.* 33.)

No. of Samples taken.	Total C.	Mn.	Si.	S.	P.
1	0·324	0·65	0·35	0·023	0·044
2	0·324	0·65	0·34	0·030	0·047
3	0·328	0·65	0·34	0·026	0·051
4	0·333	0·63	0·32	0·031	0·049
5	0·333	0·65	0·35	0·030	0·044
6	0·320	0·65	0·34	0·029	0·043
7	0·319	0·64	0·34	0·028	0·044

5-*ton Ingot.—Charge No.* 33,186. (*Ingot No.* 34.)

No. of Samples taken.	Total C.	Mn.	S.	P.
1	0·284	0·926	0·032	0·013
2	0·279	0·926	0·034	0·014
3	0·274	0·911	0·035	0·015
4	0·279	0·926	0·034	0·014
5	0·274	0·896	0·032	0·014
6	0·255	0·896	0·030	0·013
7	0·260	0·911	0·030	0·015

The compressed ingot presents to the eye a grain of a visib finer structure, and the large cleavages no longer exist; but tl only results which it is possible to produce here are those r vealed by microphotography.

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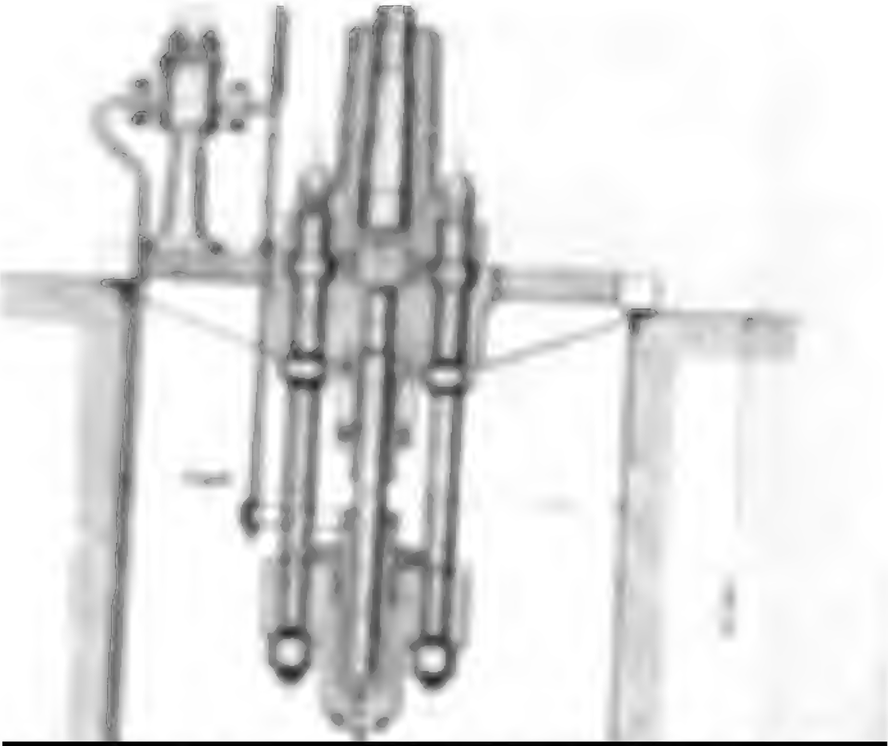

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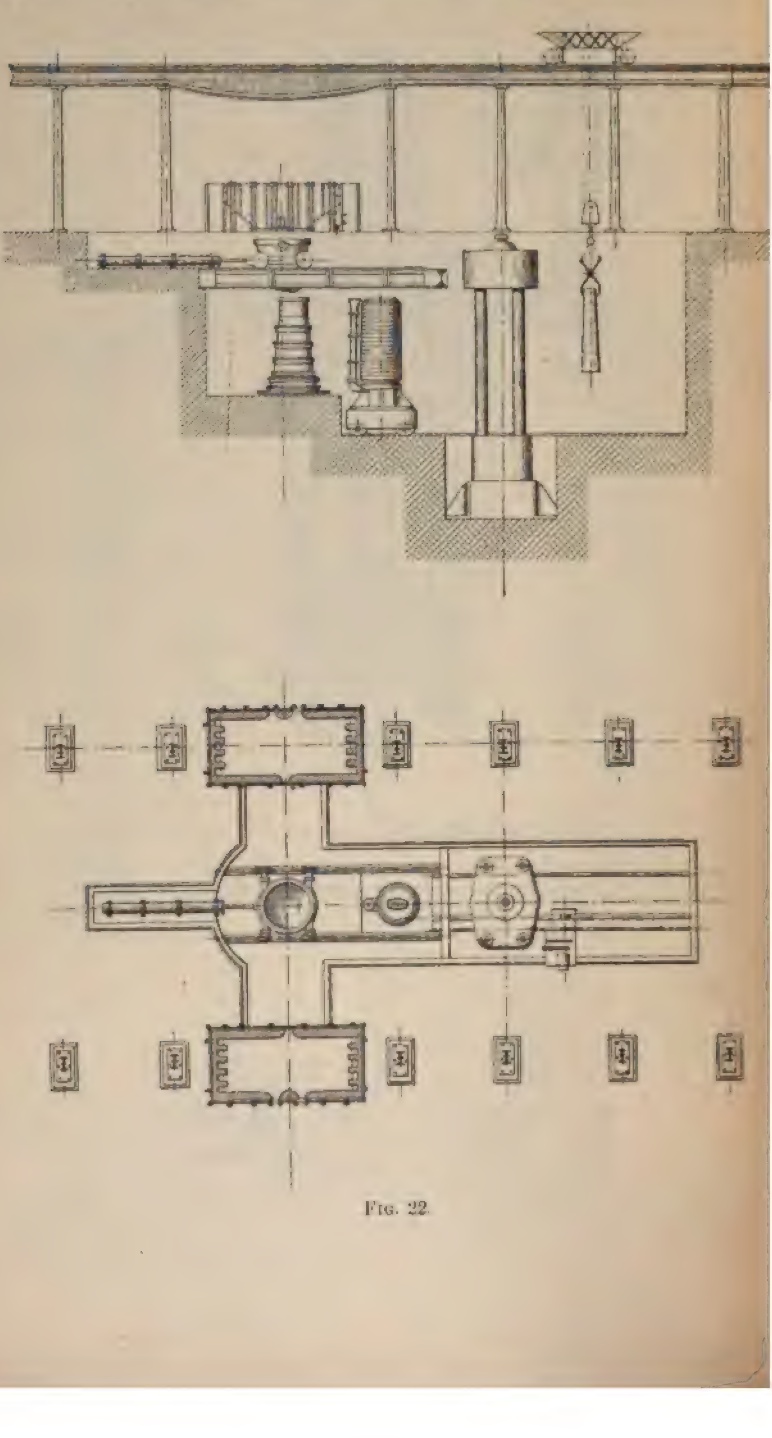

FIG. 22.

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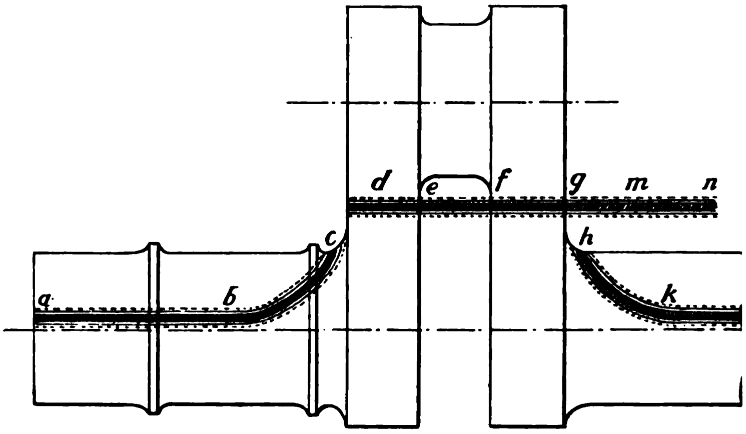
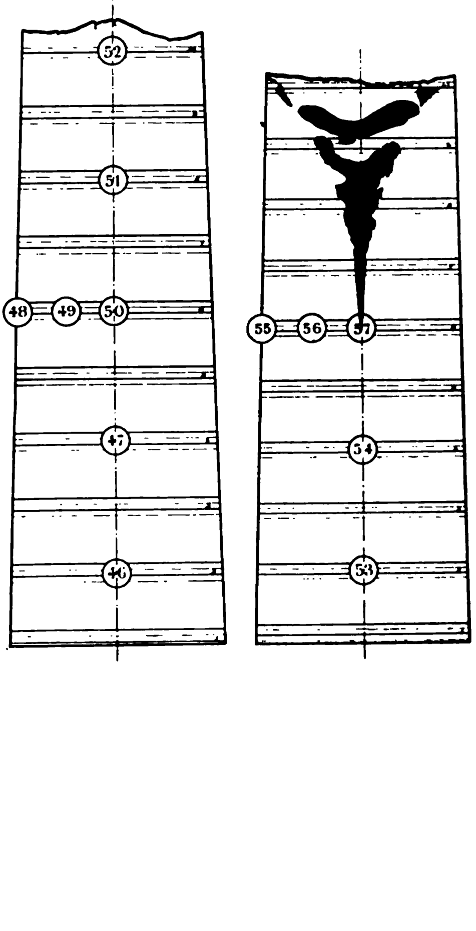


FIG. 43.

LOCOMOTIVES OF THE WESTERN RAILWAY (FRANCE).
Low-Pressure Crank Axle of the Driving Wheels.

Fig 58 Fig 59



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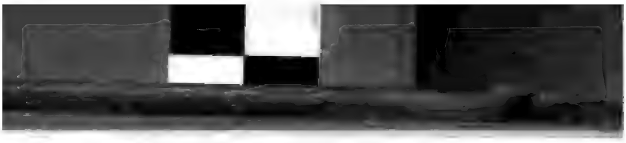

TABLE VI.—ECONOMY OBTAINED BY COMPRESSION IN THE MANUFACTURE OF ARMOUR PLATE.

	Ordinary Ingot, 20,000 Kilogs.	Compressed Ingot, 20,000 Kilogs.
Weight of rectangular armour plate obtained	10,000 kilogs.	15,000 kilogs.
(1) *Rolling or forging.*		
Steel, 20,000 kg. at	$20\,P$	$20\,(P+7)$
Coal Labour Maintenance	L	L
(2) *Finishing.*		
Labour Maintenance Hardening and annealing Haulage	K	$K \times 1{\cdot}25$
Total expenditure	$20\,P+L+K$	$20\,(P+7)+L+(K \times 1{\cdot}25)$
Deduct—		
Turnings and cuttings: 9000 kg. at 5 fr.	450·00	
Turnings and cuttings: 4000 kg. at 5 fr.	...	200·00
Then the cost of the finished armour plate is	$20\,P+L+K-450$	$20\,(P+7)+L+(K \times 1{\cdot}25) - 200$

Substituting for P, L, and K their values, which vary according to the kind of plant employed, the cost price of the total quantity of armour plate will be obtained in both cases, and consequently the price per ton.

If the selling price of the armour plate is 2 francs per kilogramme, the value will be	francs $2 \times 10{,}000 = 20{,}000$	francs $2 \times 15{,}000 = 30{,}000$

Deducting from the selling price the cost price as above there remains as the profit, R and R_1, on each of the ingots:—

For the compressed ingot: $30{,}000 + 200 - 20\,(P+7) - L - (K \times 1{\cdot}25) = R$.

For the ordinary ingot: $20{,}000 + 450 - 20P - L - K = R_1$.

To find the difference between these two profits:—

$$R - R_1 = 10{,}000 - 250 - 20 \times 7 - 0{\cdot}25\ K.$$

If the finishing costs 500 francs per ton, then $K = 5000$ francs, and therefore $R - R_1 = 8360$ francs (£334).

It may therefore be taken for granted that a compressed ingot of 20 tons yields, in the selling of the finished armour plate, a profit amounting to 8360 francs, or £334, more than that yielded by the same ingot when uncompressed. The advantages conferred by compression could, moreover, be shown

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[illegible]

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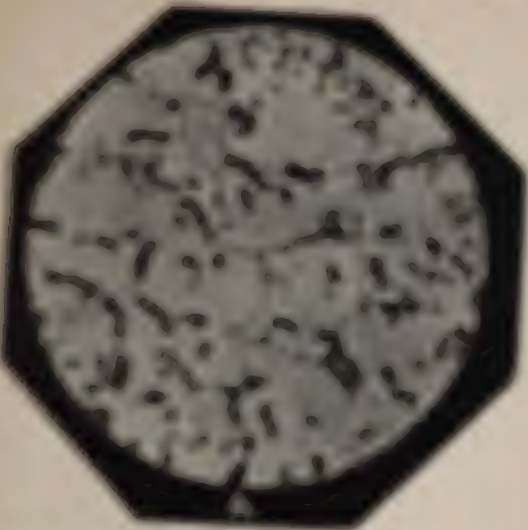
[illegible]
[illegible]

DISCUSSION.

Mr. WILLIAM BEARDMORE, Member of Council, was sorry that he could not make any very substantial remarks on the paper, because anything he might say would be purely from observation and not from actual experience. He might say that he went to the Saint-Etienne works some months ago to see Mr. Harmet's process of compressing ingots, and he spent a couple of days in investigating and thoroughly observing the process. He was so much struck by what he saw on that occasion that he immediately sent some of his engineering staff to the Saint-Etienne works, where they spent something like a fortnight, and when they came back he gave the matter full consideration, and he was so far pleased with it that he at once ordered a press for this purpose. This press was now in course of manufacture, and he hoped in the course of a short time to apply it to the solidification of armour-plate ingots. He believed that the result obtained would fully justify the large expense he had incurred in putting it down. He was sorry that he could not enter into details and give them any actual experience, as he said before, but perhaps, on some future occasion, he might have that pleasure.

Mr. E. WINDSOR RICHARDS, Past-President, had had the pleasure of knowing Mr. Harmet for something like a quarter of a century, and he knew him to be a thoroughly practical metallurgical engineer, and so he (the speaker) paid very great attention to the author's most interesting paper. They always liked when they saw an arrangement of this sort to know how it could be applied to the particular business they had in hand, and he would like Mr. Harmet to tell them whether he thought that it could be applied to the everyday working of a Bessemer steelworks making large quantities of ingots for rails, say ingots weighing 30 cwt. If it could be done he thought it would be a very great advantage, because it was just as important to have a thoroughly sound ingot for rail making as for armour-plate making. He should be glad to have his views on that matter.

PLATE [illegible]



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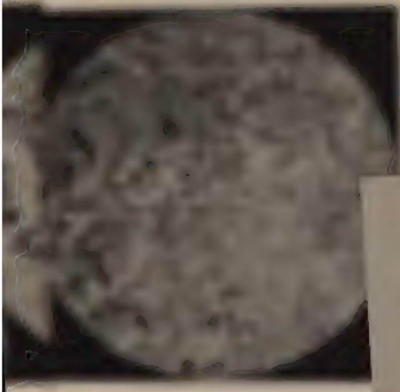

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Professor H. M. Howe (New York) said the Institute was much to be congratulated on the very excellent paper which Mr. Harmet had prepared. The method was certainly most ingenious, and appeared to have great promise. It was, of course, in competition with the Whitworth and other methods of compressing, and it appeared as if Mr. Harmet was attacking the ingot at much greater advantage than Whitworth did. When Whitworth attacked the ingot the outer shell had solidified to a solid column outside, but molten in the centre along its axis, and in order to follow up contraction of the metal he had to compress lengthwise by brute force the solid outer column, the ingot offering very great resistance to the compression. Mr. Harmet in compressing his ingot did it by wedging. If a wedge or a tapered plug were driven into a tapered hole into which it fitted accurately, the wedge or the plug would exert enormous bursting pressure against the sides of that hole. But, action and reaction being equal and opposite, the driving in of the wedge would cause the sides of the hole to exert enormous radial pressure inwards upon the wedge itself, a pressure out of all proportion to the pressure applied to the base of the wedge. This was just what Mr. Harmet did. A tapered ingot was driven like a wedge into a tapered mould which it fitted accurately; and this tapering caused the sides of the mould to exert upon the sides of the ingot a radial compression out of all proportion to the longitudinal pressure put upon the base of the ingot. He attacked the ingot where it resisted feebly. There were other methods of compression with which this must compete also. One had been successfully used in America to a considerable extent for small ingots, and he thought it attacked the ingot at still greater disadvantage. He did not know that it could be readily compared with the Harmet method. It was that of S. T. Williams. He cast a tapered ingot in an ordinary ingot mould, except that the mould was split. Then, after the shell of the ingot had solidified and become so thick that the ingot would not bleed if the support of the walls were withdrawn, the mould was opened, say for a minute, and a convex liner or plate was slipped in between the vertical surface of the mould and the vertical surface of the ingot. Then the two halves of the mould were pressed against the ingot, and so

per unit and not per cent., so that to bring them to our method the decimal point would have to be shifted two places.*

Mr. SANITER then said, with reference to keeping warm the top of the ingot, this had one advantage, that it enabled them to get the segregate into the top, where it would be cropped off; that, of course, was when not treating by the Harmet process. He must say, after reading the paper, he thought, with the other members who had already spoken, that it seemed to be an excellent way of tackling the matter; but it also had one little disadvantage as compared with the Whitworth process, and that was the gas in the steel. They all knew that the gas was gradually liberated as the steel solidified. If the steel was only under wire-drawing compression, that would not prevent the liberation of gas or the formation of blow-holes, while by the Whitworth process they had the steel under absolute pressure. With regard to the advantage of preventing the formation of large crystals in the ingots, it appeared that that was not a very important matter when the steel was to be subsequently subjected to heating and forging. With respect to the saving in cropping, that saving referred more particularly to forgings and armour-plate ingots, and there would not be the same saving in croppings in rails, because there was not 25 per cent. to begin with. In comparing the advantages in cost, also, it should be compared with another process of compression as well as with the ordinary method of manufacture of steel ingots.

Professor D. TSCHERNOFF (St. Petersburg) thought that it should not be overlooked that steel in the liquid state was as incompressible as water. Compression could therefore produce no other effect beyond hindering the evolution of the gases and preventing the formation of cavities due to shrinkage. The compression could also be effected by means of a gaseous medium, in which case its influence would be limited to the former of these two objects. If the pressure was applied by means of a piston, in accordance with the method first introduced by Whitworth on a large scale, the action of the piston compelled the upper surface of the ingot, already solidified at the outset, to

* The alteration has now been made.

CORRESPONDENCE.

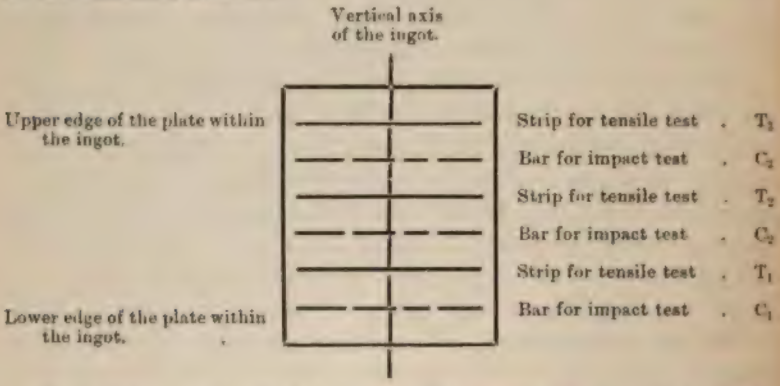
Mr. Ralph G. Scott (Leeds) asked whether the dimensions of the three ingots sketched in connection with Table V. could be added. It seemed to him that with regard to the tables several important data were not given as far as he could find out. First, the size and weight of ingots dealt with and whether these were crucible or open-hearth steel. Secondly, if the specimens for tests each contained the vertical axis of ingot, then six slabs must have been cut from the bottom, middle, and top of each ingot respectively, *i.e.* eighteen slabs in each case. If that was the case, it would be interesting to know how thick the slabs were and which specimen was taken from the uppermost slab in each case. Thirdly, in the case of the impact test, he would like to know the length of specimen, the distance apart of bearings, and whether the corners were rounded off. Fourthly, the meaning of the letters K, D, B, F, G, &c., in the fracture column. Lastly, he would like to know the exact meaning of two and four workings—that was to say, the size of original ingot and the size after the first, second, third, and fourth workings respectively—and whether the process was one of hammering or rolling; if the former, what was the size of hammer?

Mr. Harmet, in reply, warmly thanked the Council and the members, and especially those who had taken part in the discussion, for their kind appreciation of his paper, and the attention they had given to the problem of compressing ingots by wire-drawing. The points raised in discussion were of a most interesting character, and merited earnest consideration, but he would endeavour to reply in a few words only. He had been asked by Mr. Windsor Richards if the process was applicable in the case of a regular output of rails from Bessemer steel ingots of 1½ tons. This question had already been asked by Belgian and Russian manufacturers, and he would answer it first from the mechanical point of view, by stating that they had designed a press to compress simultaneously four ingots of 2 to 2½ tons

liquid metal while compression was going on, and what was the nature of these gases. Mr. Vaughan Hughes desired to know whether he had confined his attention solely to the avoidance of cavities and defects due to the shrinkage of the steel, regardless of the chemical aspect of the question, and it had been suggested by Mr. Saniter that compression by wire-drawing alone appeared to him an insufficient means to prevent the liberation of the gases. These three questions were supplementary, and were worthy of being thoroughly discussed. Unfortunately he was compelled to give but a short reply, which would deal at once with all three. The compression by wire-drawing was a mechanical operation, by means of which the formation was avoided of pipe and other defects resulting from the contraction which took place during the period of cooling from the liquid state to the temperature at deep red. It was assumed that the liquid metal had been carefully prepared within the furnace before pouring into the mould. The compression was introduced with the clearly defined object of combating the evil effects of shrinkage, because it was by this means alone that this end was attainable. The effect of shrinkage could not be eliminated either in the furnace before tapping or subsequent to cooling. By compression this object was fulfilled in a satisfactory manner, and at the same time crystallisation, liquation, and segregation were diminished, as he (the author) had explained. Further than this, the operation, though of a purely mechanical nature, became accessory to the furnace in which the metal was produced in cases where the chemical reactions within the furnace had not been able to take place in a measure suitable for the production of a perfect metal; and one which should evolve no gas during cooling. Compression by wire-drawing, in fact, had the effect of retaining the gases in the metal in solution—firstly, owing to the pressure exerted throughout the mass; and secondly, by the rapid cooling which took place in the head of the ingot, by causing it to rise into the cold parts of the ingot mould. The shell was thus completely closed, and at the same time no hollow space could form internally where the gases might accumulate. The shell was supported over its whole surface by contact with the walls of the mould, which exerted a powerful squeezing action; it was also supported by

caused, prevented, or at least very much diminished, the evolution of the gases. By crushing in the external shell of the ingot and by forcing it constantly upon its own centre according as contraction proceeded, the formation of pipe and of cavities about the axis was hindered.

In reply to Mr. Scott, the author stated that the ingots used for making the tests described in Tables II., III., and IV. were identical with those represented in Table V. All these ingots were of open-hearth steel. From each ingot only three plates were cut—one from the bottom portion, one from the middle, and one from the top. From each plate were prepared three strips for tensile tests, and three bars for impact tests. The manner in which these were cut from each plate was indicated in the annexed sketch:—



The plates were all $1\frac{3}{16}$ inches thick, and were cut in such a manner that the longitudinal axis of the ingot always coincided with the centre of the thickness. The impact bars were $6\frac{3}{8}$ inches long, the distance apart of the supports being $4\frac{3}{4}$ inches. These supports were slightly rounded at the top, the radius being $\frac{1}{16}$ inch. The face of the drop-hammer was similarly rounded off, with a radius of about 1 inch.

The letters A, B, C, D, E, F, G, H, J, K in the fracture column refer to a classification currently used in France to denote the various aspects presented by the fracture. A is a fibrous fracture exhibiting a surface entirely cupped (*Cassure à nerf à coupelle complète*).* B is a fibrous fracture, on the surface of which the cupped part is incomplete (*Cassure à nerf à*

* *For the* English rendering of these terms the Institute is indebted to Mr. R. G. Scott.

THE APPLICATION OF ELECTRIC POWER IN THE IRON AND STEEL INDUSTRIES.

By D. SELBY-BIGGE (Newcastle-on-Tyne).

In the year 1894 the author had the honour of reading before this Institute two papers dealing with the subject of Electric Power Transmission, having regard especially to the driving of works machinery by means of electricity. At that time the subject was a comparatively new one to the owners of works in Great Britain. The papers read were purely of a technical nature, and dealt with the methods the author then thought most suitable to be employed in driving works electrically. Since that date a great number of papers have been read by well-known authorities on this subject. In bringing another communication before this Institute it is now the author's endeavour to read a paper on somewhat different lines, and one which will prove not only of interest but of actual use to works owners and managers in England. The paper therefore will deal chiefly with actual facts and figures, and with data of a practical nature, collected from a great number of different sources.

During the past twelve years the author has been almost exclusively engaged in the remodelling of the driving arrangements in engineering works, iron and steel works, shipyards, factories, and mining operations from steam to electricity, and he has almost invariably been met with the question—Can you show us by any facts or figures actual savings which can be directly attributable to the change from one system to the other? It has not, however, been possible for him to deal with this matter in the form of a paper until the present time, as in the early days no data were available, and even in subsequent years accurate data have been most difficult to obtain. The following cases and figures may, however, prove interesting to the members of this Institute.

order to have an accurate comparison of the two systems, several tests were made, extending over some days, with the following results: The reduction in steam consumption was found to be 40 per cent. and the reduction in coal consumption $32\frac{2}{10}$ per cent.

Before a meeting of the Franklin Institute in 1901, Mr. Samuel Vauclain, Superintendent of the Baldwin Locomotive Works at Philadelphia, U.S.A., stated that if electric driving in their works should be abandoned the manufactured product would cost 20 to 25 per cent. more for labour, and the floor space would have to be increased 40 per cent. to maintain the present output.

In an excellent article written by Mr. Alexander Richardson, upon Messrs. Vickers, Sons, & Maxim's works at Barrow-in-Furness, and published in the July number of *Traction and Transmission*, he says:—

"No special data have been taken as to the cost of running this station separately, but it may be noted that the cost per unit generated during 1901 at the engineering works station was 0·77d., which includes coal, wages, water, repairs, and all works costs. The economy resulting from the substitution of electric power for steam is shown by the fact that the average monthly coal consumption for three winter months in 1898, when only steam power was used in the shipyard, was 476 tons, whereas for the corresponding period in 1899, after electric power was adopted, the average coal consumption was 232 tons, being almost exactly half the total required for steam power. This, too, notwithstanding the fact that many new machines had in the interval been added in the platers' shed, and that the amount of lighting done had been more than doubled. The true saving is probably nearer 60 per cent. than 50 per cent. if this extra load be taken into account."

At a large colliery in South Durham the pumps were originally of the spear rod type, worked from bank, and the pumps delivered about 1000 gallons per minute against a head of 400 feet.

Owing to the room which these pumps occupied in the shaft, and it being desired to put in another cage, which could not be done with the pumps in the shaft, the pumps were removed and in their place was substituted a horizontal compound coupled engine of 400 horse-power, one 250 K.W. dynamo arranged to

With electrical driving of hauling gear at the Ewald Colliery, Germany, it has been found that, not taking into account depreciation, discharging 1 ton kilometre of coal from the mine costs about 3·39 pfennigs (one-third of a penny).

A balance-sheet for July 1895 shows a clear saving in cost against that of July 1894 of 5512 marks, the economy being effected by the electric hauling gear.

The quantity of coal discharged up to July 1894 for twenty-five working days amounted to 107,000 truck kilometres at 0·6 of a ton per truck, fifty horses being at work, so that the monthly work of each horse amounted to $\frac{107,000}{50}$ = approximately 2140 truck kilometres, or $2140 \times 0{\cdot}6 = 1284$ ton kilometres without counting trucks carrying bricks, wood, or lime, or running empty.

The daily work of each horse was $\frac{2140}{25} = 85{\cdot}6$ trucks per kilometre, or $\frac{1284}{25} = 51{\cdot}36$ ton kilometres.

The monthly cost per horse is as follows:—100 marks paid for hiring; 54 marks, wages for driver, proportion of expenses for stable-boys, &c., &c., together, 154 marks for fifty horses; therefore = 7700 marks, not counting 6 marks per horse, or 300 marks per month for fifty horses for shoeing, water, and amortisation of the underground stables.

If, therefore, the daily work of the horses is 85·6 trucks per kilometre, there would be 51·5 horses necessary for the month of July 1895 for the whole transport of 118,962 truck kilometres in twenty-seven working days, which would mean a cost of $51{\cdot}5 \times 154 = 7931$ marks.

Exclusive of amortisation of the capital the cost of the mechanical hauling gear is as follows:—

		Marks.
1	Foreman	190·00
2	Day attendants	197·75
4	Night attendants	473·45
3½	Men for rope repairs	328·07
175	Different amounts for extra work, &c.	562·15
	Total of wages	1751·42
	Extra expenses	145·82
	(320 volts, 110 amps. = 35·2 K.W.) for the steam engine $\frac{35{\cdot}2}{0{\cdot}7} = 50{\cdot}3$ H.P.	521·51
	(1 H.P. hour = 0·024 mark monthly, 27 days × 16 hours × 50·3 × 0·24 = 521·51 marks.)	
	Total working costs	2418·75

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COMPARATIVE COST OF WORKING HYDRAULIC AND ELECTRIC LIFTS.

Type of Lift.	Load.	Source of Power.	Travel in Feet.	Cost of Average Round Trip up and down in Pence.	Number of Trips per Penny.	Remarks.
Electric	7 cwt.	Manchester Corporation	50	·159	6·3	Observed. Conditions Unfavourable. Current at 2½d.
Hyd. Suspended H.P. .	7 cwt.	Manchester Corporation	50	·29	3·45	Calculated from Published Scale.
Hyd. Suspended L.P. .	7 cwt.	Manchester Corporation	50	·445	2·2	Calculated at 6d. per 1000 Gallons. Pressure, 50 lbs.
Electric	9 cwt.	Private Supply	50	·066	15·	Observed. Conditions Ordinary. Current at 2½d.
Hyd. Suspended H.P. .	9 cwt.	London Hyd. Power Co.	50	·277	3·6	Calculated from Published Scale.
Electric	9 cwt.	Glasgow Corporation	50	·061	16·4	Observed. Current at 2½d.
Hyd. Suspended H.P. .	9 cwt.	Glasgow Corporation	50	·212	4·7	Calculated from Published Scale.
Hyd. Suspended H.P. .	12 cwt.	London Hyd. Power Co.	50	·35	2·86	Observed.
Hyd. Suspended H.P. .	9 cwt.	London Hyd. Power Co.	50	·287	3·5	Observed.
Hydraulic Ram. H.P. .	12 cwt.	London Hyd. Power Co.	50	·42	2·4	Observed.

this the author has drawn upon a number of cases of different kinds and in different parts of the country, showing the rate at which the works owner can generate his own electricity. These figures are taken from actual examples of every-day working, and are not in any way test figures taken for the purpose of this paper. Taking these figures as a basis, it is an easy matter for a works owner, once having ascertained the total horse-power which will be involved in the driving and lighting of the entire works, to see for himself at what expenditure per annum he can run his works upon the new system.

Cost of Electricity delivered on Switchboard.

Test of 139½ *hours, November* 17*th to* 23*rd* 1901, *Britannia Works.*

Mean current (amps.)	3464
Mean pressure (volts)	125
Mean power (watts)	433,000
Mean electric h.p.	580·42
Board of Trade units	60,403
Weight of steam per B.T.U.	27·52 lbs.
Weight of coal per B.T.U.	3·04 lbs.

Cost per B.T.U.		Cost per week.
Coal 3·04 lbs. at 11s. 6d. per ton	0·187	£47 4 0
Water 27·52 lbs. at 3½d. per 1000 gallons	0·00963	2 8 6
Stores	0·00995	2 10 0
Wages	0·06625	16 13 3
Repairs *	0·0159	4 0 0
Superintendence	0·01192	3 0 6
Net cost per B.T.U.	0·30065d.	£75 15 9
Interest and Depreciation on £15,000 at 10 per cent. per annum	0·099d. per unit.	

Cost per E.H.P. per Hour.

Coal 2·27 lbs. at 11s. 6d. per ton	0·1395
Water 20·53 lbs. at 3½d. per 1000 gallons	0·00718
Stores	0·0074
Wages	0·0494
Repairs	0·01185
Superintendence	0·0089
	0·22423d.

Mean I.H.P. at 75 per cent. efficiency, 773. Coal per I.H.P., 1·705 lbs. Water per I.H.P., 15·4 lbs.

The author is indebted to Messrs. Richardson, Westgarth & Co., Limited, West Hartlepool, for the following information on the subject of the economy effected by the introduction of electric driving into their works. The following is a rough summary of the changes which have been effected :—

These works were formerly driven by about thirteen small

* Includes labour of keeping 134 arc lamps in repair.

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Cost of Power per £ Wages Paid.

Coal and Gas.				*Electricity.*			
2nd May 1893 to 24th April 1894.				30th April 1900 to 30th April 1901.			
Wages . .	£64,885	0	0	Wages . .	£126,700	0	0
Cost of power	2,337	0	0	Cost of power	2,578	0	0
=8·66d. per £ wages paid.				=4·88d. per £ wages paid.			

Taking the case of another shipyard which was previously driven by gas engines, the author has received the following particulars: "We have no hesitation in saying that we are getting at least 30 per cent. more power out of our machines since we adopted electric power instead of the gas engines we used before.

"As far as the cost per B.T. unit goes, we have lately had readings taken, and find that last year's works out at about 0·8 of a penny; this is taking into consideration the depreciation on our plant, interest on capital, repairs, and in fact everything which we can possibly put down against this account."

The average output would not exceed 250 to 300 horse-power.

The author is indebted to the managing director of another large shipyard in the North of England for the following statement: "Some years ago, just about the time when we first introduced electrically driven machines, we put in new boilers in place of the old ones, and while it must be remembered that the new boilers are more efficient than the old ones, I would say in general terms that our coal consumption has been reduced by some 40 per cent., although the amount of machines driven electrically is now greater than those which were formerly driven by steam, and consequently the reduction may be even greater than the percentage I mention above."

In a letter the author has received from Colonel R. E. Crompton, he states:—

"In our own works, which are on a somewhat extended scale, the substitution of electric driving for the old shafting system has approximately halved our bill for power; in fact, the whole of the driving of the works and tools for about 1300 men is practically supplied by one 120 K.W. set fully loaded, and it is only when we are testing that we have to run two sets of this size, whereas by the old system we should have had to run two 200 horse-power engines continuously."

Another very interesting case, although not in full operation as yet, but one which shows conclusively the enormous advan-

MOTOR TESTS.

Designation of Machine.	Work Done. Maximum.	Work Done. Average.	E.H.P. Absorbed by Motor with Machine Running Light.	E.H.P. Absorbed with Load on.	Size of Motor Recommended. B.H.P.	Remarks.
Large plate edge planer	35'×1".	7/8" or 1" plate.	14·75	24·5	30	Cut 0·05" thick on 1" plate 4' long at time of test. This machine took 29·5 H.P. to reverse.
Small plate edge planer	15'×3/4".	5/8" to 3/4" plate.	6·33	20·1	25	Cutting 3/4" plate 22" long. 21 H.P. to reverse.
Plate straightening rolls	4' 6"×4' 6'×1 1/4".	10"×1/2" to 15"×3/4".	4·5	6·1	...	10"×1/2" plate.
				16·1	...	Plate 4' square by 1 3/16" thick.
				14	15	Same plate on slow speed. This machine took 19·1 E.H.P. to reverse.
Cold saw	16"×6" girder.	About 12"×6".	1·45	2·6	7	Cutting 12"×3 1/2"×1/2" channel. Saw fitted with friction gear for feed, which prevents a heavy load.
Punch shears and angle cutter	12" shear, 7/8" plate. 1 3/8" hole, 7/8" plate.	3/4" hole, 1/2" plate.	3·85	6·0	10	7/8" hole, 5/8" plate. 25 to min.
				8·85	...	1 3/8" hole, 3/4" plate. 20 to min.
				5·15	...	Shearing 10"×1/2" plate.
				4·9	...	Cutting 3"×3"×3/8" angles.
Large ending machine	Knives 22 1/2" long.	...	1·88	15·42	15	Ending 20"×7 1/2" girder, 1/2" web, 1" flange.
Straightener and angle cutter	Angles and small bars.	...	1·53	11·55	10	Cutting 3 1/2"×3 1/2"×1/2" angle (momentary load).
				6·15	..	Straightening 6"×6" angle piece.
Shafting driving six radial drills	1" holes.	3/4"	3·7	7·5	8	All six drills at work. 3/4" holes in girder steel.
Large straightener	20"×7 1/2" girders.	12"×6" girders.	3·96	6·5	8	Straightening 20"×7 1/2" girder.

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MOTOR TESTS—(*continued*).

Designation of Machine.	Work Done. Maximum.	Work Done. Average.	E.H.P. Absorbed by Motor with Machine Running Light.	E.H.P. Absorbed with Load on.	Size of Motor Recommended. B.H.P.	Remarks.
Vertical shipyard drills and countersinks	$1\frac{1}{4}''$ holes and $1\frac{3}{4}''$ countersinks.	...	Driving counter-shaft off which 2 per cent. drills are worked, 3·5 E.H.P.	7·5	7	$1''$ hole and $1\frac{1}{2}''$ countersink; two machines doing 280 holes in 8 minutes.
Punch and shears . .	$1\frac{1}{4}''$ holes in 1 .	Plate.	2·7 E.H.P.	6	12	$\frac{7}{8}''$ holes, $\frac{5}{8}''$ plate, 36 strokes per minute.
	Shearing $1''$.	,,	...	15	...	Shearing $\frac{5}{8}''$ plate 16 feet per minute.
,, ,, . .	,,	,,	2·75 E.H.P.	3·5	12	$\frac{5}{8}''$ holes, $\frac{1}{2}''$ plate, 34 strokes per minute.
				11	...	Shearing $\frac{1}{2}''$ plate, 11 feet per minute.
Mangle rolls . . .	$1\frac{1}{8}''$ plates.	$\frac{3}{4}'' \times \frac{5}{8}''$.	4·5 E.H.P.	13·5	15	Motor is a series motor, with a tramway controller; belt drives direct to machine, and motor is reversed when mangling. This arrangement has given most excellent results.
Wood Working Tools.						
Hatch boring machine .	$1''$ holes.	$\frac{5}{8}''$ holes.	2·05 E.H.P.	3	3·5	Boring $\frac{5}{8}''$ hole, in hatch $22''$ broad, in 2 minutes.
Wood planing machine .	...	...	4·4 E.H.P.	8·8	8	Cutting $\frac{1}{8}''$ off plank $10''$ broad $\times 17'$ long in 1·5 min.
Wood planing machine (heavy)	...	...	4·5 E.H.P.	16	16	$\frac{1}{8}''$ off plank $7''$ broad $\times 13'\ 6''$ in 30 seconds.
$32''$ circular saw . .	...	...	0·9 E.H.P.	14·8	15	Cutting $3''$ teak—handfed—$14'$ long in 20 seconds.
Heaviest class of shearing machinery	Steel tyres of loco. wheels.	General scrap.	2 E.H.P.	29	30	Machine cut about 35 pieces $11'' \times 1\frac{1}{8}''$ section in 1 minute.

MOTOR TESTS.

Works Department or Machine.	Work done by Motor.		E.H.P. Absorbed.				Size and Type of Motor.	Remarks.
	Total of Machines on Motor.	Usual and Average Machines on Load.	Shafting and all Machines Light.	Average Machines Light.	Average Machine Loaded.	Maximum Load on Motor.		
Fitting Shop Motor.	2 9" centre lathes. 1-12" centre lathes. 1-3' centre chuck lathe. 1 Planing machine, 9 ft. stroke. 1 Slotting machine. 1 Milling machine. 1 Shaping machine. 1 Punch and shears machine. 2-2½" Vertical drills. 1 Emery wheel. 1 Cold saw (hack). 1 Fan supplying 9 smiths' hearths. Shafting: 20 ft. × 3 in. C shaft; 5 others to 10 ft. long.	2-9" centre lathes. 1-12" centre lathes. 1-3' chuck lathe. 1 Slotting machine. 1 Drilling machine. 1 Emery wheel. Fan.	Shafting alone, 1·75 E.H.P. All machines light. 62 E.H.P.	3·7 E.H.P.	9·5 E.H.P.	14·9 E.H.P., with fluctuations, to 19 E.H.P.	20 B.H.P.	
No. 1. Galvanizing House Motor.	4 Large galvanizing pots, each for 20 tons metal. 2 Drying machines, attached. 1 Large sheet-stretching machine. 1 Large corrugating machine (press). 2 Circular shearing machines, counter-shafting and belts.	All machines, pots, and drying machine continuous, and others intermittent.	Shafting alone, 1·5 E.H.P.		Average full load, 11·2 E.H.P.	Fluctuation to about 18 E.H.P.	20 B.H.P.	

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Tests on Cranes, Quick-Motion Overhea

Works Department.	Size and Type of Travelling Crane.	Work done by Crane.		Actual Tests on Crane—	E.H.P. Absorbed. Crane Light.	
		Average.	Maximum.	Motion.	Starting Effort.	Running Power.
No. 1 Crane—Plate mills loading.	5-ton 3-motor crane. Works in exposed position, both in and out of shop.	1 to 3 tons.	4½ tons.	Lifting.	13·4	0·5
				Traversing.	14·8	7·7
				Travelling.	23·6	11·8
No. 2 Crane—Plate mills floor.	5-ton 3-motor crane. Works under cover.	1 to 2 tons.	4 tons.	Lifting.	18·0	9·6
				Traversing.	20·6	9·35
				Travelling.	28·5	11·3
No. 3 Crane (new)—Plate mills loading.	6-ton 3-motor crane. Built and erected by Dowlais Cardiff Works. Works in exposed position, both in and out of shop.	1 to 3 tons.	4½ to 5 tons.	Lifting.	22·3	9·5
				Traversing.	11·3	6·2
				Travelling.	29·5	12·0

NOTE.—The starting efforts given above can be regarded only as approximate, bein
circuit. One longitudinal trolley wire only employed, the return being t
are seldom exceeded under actual working conditions in these works.

MOTOR TESTS.

Taken 18th August 1902.

Description of Machine.	Work done by Machine.	E.H.P. Absorbed.		Type and Size of Motor.	Remarks.
		Light.	Loaded.		
3-ton skull-breaking winch.	Lifts ball weighing 3 tons 8 cwt. to height of 50 feet at speed of 60 ft. per min. (timed).	8·5	17·8	2-pole open type armature at bottom, 18 E.H.P., series wound.	This winch is of ordinary band pattern, driven through works and spur gear, with brakes and clutch. Water starting and regulating switch.

A table of machine tests in a somewhat different form is appended :—

Condensing Plant.

One 10 h.p. motor 220 volts driving direct coupled 3-in. centrifugal pump, driving also with belt air pump $9\frac{1}{2}$-in. diameter by 9-in. stroke, and feed pump 2-in. diameter by 9-in. stroke. Boiler pressure 200 lbs.

Operation.	Revs.	Amps.	Volts.	Vacuum.	Electrical H.P.	Electrical H.P.
					Total.	Actual per Operation.
Centrifugal pump	1100	6	240	...	1·9	1·9
Ditto with air and feed pump	160	12	240	27 in.	3·8	1·9

Brass-Shop Motor. 5 *Horse-Power.* 240 *Volts.*

Operation.	Revs.	Volts.	Amps.	Electrical H.P.	Electrical H.P.
				Total.	Actual per Operation.
Motor and shaft	220	250	7·0	2·3	2·3
Disc grinder, 18-in. emery discs running light	1800	246	8·5	2·8	0·5
Facing $6\frac{1}{2}$-in. brass valves	1800	246	24·0	7·9	5·6
6-in. capstan lathe (light)	...	248	9·75	3·2	0·9
Turning and screwing $1\frac{1}{8}$-in. brass bars for $\frac{7}{8}$-in. tap bolts	...	248	12·0	4·0	1·7
Parting ditto	...	248	10·0	3·3	1·0

Air Compressor, Belt driving from Motor.

Operation.	Revs.	Volts.	Amps.	Electrical H.-P.	Remarks.
Motor, shafting, and pumps . . .	175	230	22	6·7	Air compressor, 9-in. diameter, 10-in. stroke
Pumping up to maximum pressure . .	170	230	70	21·5	Maximum pressure, 80 lbs.

Pattern Shop Motor. 15 *Horse-Power Motor.* 220 *Volts.*

Operation.	Revs.	Amps.	Volts.	Electrical H.P.	Electrical H.P.
				Total.	Actual per Operation.
Motor and shafting . . .	170	9·5	233	2·9	2·9
Circular saw, 2 ft. 8 in. diameter, running light	800	10·5	233	3·2	0·3
Cutting yellow pine 11 in. deep, 7 ft. per minute . . .	Max.	40	233	12·4	9·2
	Min.	18	233	5·6	2·4
	Average	29	233	9	5·8
Thickness machine, 2 ft. 6 in. bed, running light	3800	12	230	3·7	0·8
Surfacing yellow pine 11 in. wide, 13 ft. per minute . . .	...	17·9	232	5·5	1·8

37 *Horse-Power Motor.*

Operation.	Revs.	Amps.	Volts.	Electrical H.P.	Electrical H.P.
				Total.	Actual per Operation.
Motor and shafting . . .	...	12	230	3·7	3·7
Circular saw, 3 ft. diameter, running light	1200	21	230	6·4	2·7
Sawing yellow pine 11 in. deep, 20 ft. per minute . . .	...	71	230	21·5	15·1
Circular saw, 33 in. diameter, running light	...	26	230	8·0	4·3
Cross cut lignum-vitæ, 9¼ in. deep × 18 in. long	...	41	230	12·6	4·6

engines, every blast-furnace owner would have a very large surplus of power for his steel or other works, in the form of electricity or otherwise.

It would be impossible to overrate this new development in power production. In Great Britain really large sources of water power are practically unknown, and the sources from which electricity can be produced most economically will be undoubtedly due to the development of large power gas-engines making use of the surplus gases from the blast-furnaces, which would otherwise be wasted.

Engines have been constructed and are at work of 1200 horse-power, and an engine of this type is now building for no less than 2500 horse-power.

The Development of Electric Power Companies.

During the past two years great activity has been displayed in England in the formation of large electric companies, dealing with extensive tracts of country and covering under their parliamentary powers vast areas for the supply of electricity in bulk to tramway companies, electric light companies, works owners, and for manufacturing purposes generally.

In certain cases, and under favourable conditions, with regard to the district to be supplied, these companies may meet with success, but in many cases the author is of opinion the matter has been rushed into somewhat precipitately. Taking, for instance, a district of a fairly concentrated character, one in which a large number of small works and factories exist, absorbing each, say, 100 to 200 horse-power, it might be found that with the power company supplying them with electricity at 1d. per unit it would be more profitable and convenient to them to obtain their power from the company in preference to laying down their own plant. In cases such as this, the power companies should have a good field before them. When, however, the power company enters the field in districts where all the works are of an extensive character, and absorb 500 to 5000 horse-power in electric current each, the case changes its aspect, and it will be found that it will be more profitable for the works owners to produce their own power.

The enormous developments and strides which have been made during the past ten years in this branch of engineering tend in the direction that every works owner and engineer should acquire a thorough knowledge of this subject.

We have in Great Britain been somewhat slow in making use of all the advantages which electricity has enabled us to reap. In many parts are to be found the same old low-pressure boilers, which have done service for the past thirty years, with working pressures as low as 15 lbs. per square inch. In other works are still to be found the same old beam engines constructed in the days of Watt and Stephenson. Works are still to be found in which over 100 small high-pressure and non-condensing engines are distributed with their mileage of steam pipes throughout the works—little or no attempt having been made to improve this state of affairs. It is in cases such as these the author trusts this paper may be of service, by showing clearly and in a practical manner the actual result which would accrue from the remodelling of the driving arrangements upon the electrical method.

In no country have we finer examples before us of the achievements of electricity as a motive power than in Germany, and we must all admire the skill, ingenuity, and above all, the enterprise of our German friends in this direction.

There are many outlying advantages which would accrue were works and industrial establishments driven electrically. There would be an enormous reduction in the smoke produced in large manufacturing centres, and a proportionate increase in a healthier state of things for the inhabitants.

In these days, when the idea of coalfields giving out is mooted, there would be a perceptible difference in the quantity of our coal consumption, which, although perhaps unpalatable to the coal-owner, would be most welcome to the manufacturer, who aims at the lowest cost of production. The application of electric power to the iron and steel, engineering, and manufacturing industries in Great Britain has certainly not developed with anything like the rapidity with which it has progressed in America and on the Continent, and the author has often wished to ascertain the reasons underlying this retarding influence.

Generally speaking, the powers and responsibility vested in

abroad offer a case in which enormous savings could be effected. The reduction in working costs of a number of shipyards with which the author is acquainted has varied between 30 per cent. and 60 per cent. If this same saving could be effected in similar establishments, such as our Government dockyards, the result would be highly beneficial to the country.

In placing this paper before the Iron and Steel Institute, the author's one endeavour has been to show what are the immense possibilities and advantages to be derived from carefully considered electric power schemes. He has done his best to put the subject forward plainly and in a practical light, and if in the preceding pages he has given data, information, and subjects for thought and consideration to the members of this important Institute his task will have been amply repaid.

The author's thanks are due to the following firms for information kindly placed at his disposal:—

The Lahmeyer Electrical Co., Ltd., London; Messrs. Siemens Bros. & Co., Ltd., London; Messrs. Laurence Scott & Co., Ltd., Norwich; Messrs. Richardsons, Westgarth & Co., Ltd., Hartlepool and Middlesbrough; Col. Crompton, London; Messrs. Ernest Scott & Mountain, Ltd., Newcastle-on-Tyne; Messrs. J. H. Holmes & Co., Newcastle-on-Tyne; Messrs. Dorman, Long, & Co. Ltd., Middlesbrough; Messrs. Archibald Smith & Stevens, London; The Westinghouse Co., London; Mr. Alexander Siemens, London; Professor Salomons, Frankfurt; The Allgemeine Electricitäts Gesellschaft, Berlin; The Compagnie Internationale d'Electricité, Liége; Messrs. Guest, Keen & Nettlefolds, Ltd.; Sir James Laing & Sons; Messrs. Short Bros.; Messrs. Craig Taylor; and Messrs. Scott & Co.

The President said they were very much indebted to the author for putting so clearly and succinctly before them his experience, which was a very extensive one, as to what had been done in electrical development in various parts of England.

There was another excellent paper by Mr. Kylberg, of Benrath, near Düsseldorf, and he was very sorry that they would not have time to read it in full. The Secretary would read an abstract of the paper, and then they could discuss it in conjunction with Mr. Selby-Bigge's paper.

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in particular, which are laid out for production on a large scale, have achieved wonders in the use of electricity although they have only recently begun to employ gas-driven engines. These American appliances have often been introduced into Europe without regard as to whether they were adapted to European conditions, with the consequent result of occasional failure. The author proposes in the following paper to describe some developments based on American experience and adapted to European requirements.

Section I.

Gas-Driven Engines for Generating Electricity in Central Stations.

Descriptions of the central power stations and gas-washing plant at the Differdingen ironworks and at the Düdelingen Eisenhütten-Aktienverein in Luxemburg appeared recently in *Stahl und Eisen*,* in which much information was given regarding the consumption of gas per horse-power per hour, besides a number of analyses. Additional interesting facts have since then been noted during the long period of constant working of the blast-furnace gas engines at Differdingen, and by the kindness of the managing director the author has been permitted to publish these. In Differdingen there are nine blast-furnace gas engines of the Cockerill system, each of which consumes, according to the various tests made, 2·9 cubic metres of gas per horse-power per hour. Of these nine gas engines, each of 600 horse-power, six are available as blowing engines for the four blast-furnaces, and the remaining three for the generation of electric energy for the works. Besides these there are two smaller gas motors, each of 75 horse-power, for the purpose of electric lighting. The gas-washing installation at Differdingen is also working at the present time in a manner which exceeds all anticipation. The results of trials have shown that the gas which comes direct from the blast-furnace contains 10 grammes of dust per cubic metre. In observing this gas in its progress through the cleansing process, the following facts may be noted.

* Vol. xxi., pp. 433-459, 489-514.

SECTION II.

Electric Shunting and Mine Locomotives (Fig. 1).

The great advantages of the utilisation of electric power as compared with steam are particularly noticeable in this connection, as is proved by the reduction in the cost of working and an efficiency hitherto unattainable. The following are the two types of locomotives which have proved most serviceable: first, the shunting locomotive of medium tractive power and high speed; and, secondly, mine locomotives of high tractive power and low speed. Both of these types are distinguishable from one another chiefly by their general mode of construction. The following are the chief points in the construction of standard electric locomotives. Each axle is driven by a special motor, by which means great efficiency and high tractive power are assured. The motors are moreover arranged that any one of them can be cut out if desired, and as the result the speed of the engine can be regulated according to the load. The shocks experienced at starting and stopping are also less severe. The accompanying tables give the dimensions and capacities of the standard types of locomotives as constructed by the Benrath Engineering Company.

Standard Mine Locomotives.

Minimum Gauge for this Type.	Number of Motors, *i.e.* Axles.	Power of the Engine.				Dimensions.				Weight, Including Electric Equipment.
		H.P.	Tractive Force on the Hook.	Speed when Fully Loaded.	Gross Weight which can be Hauled on the Level.	Minimum Wheel Base.	Maximum Length over the Buffers.	Maximum Width over Footboards.	Clear Height, Excluding Trolley Arm.	
Mm.			Kilog.	Kilom. Per Hour.	Tons.	Mm.	Mm.	Mm.	Mm.	Kilog.
425	1	10	250	8	20-25	700	2500	1000	1250	2,500
425	1	15	250	12	20-25	700	2500	1000	1250	3,000
600	2	25	600	9	50-60	1000	4000	1250	1500	6,000
600	2	25	1200	4·5	100-120	1000	4000	1250	1500	9,000
700	2	30	1200	6	100-120	1000	4000	1250	1500	12,000
700	2	45	1500	7	120-150	1200	4000	1250	1500	14,000
700	2	60	2000	7	150-200	1200	4500	1500	1500	16,000
700	2	75	2000	9	150-200	1200	4500	1800	1500	18,000
700	2	90	2500	9	200-250	1500	5000	1800	1600	20,000
1000	2	110	2500	11	200-250	1500	5000	2000	1600	22,000
1000	2	150	3000	12	250-300	1850	5300	2000	1800	25,000

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special attention to the avoidance of the use of wire ropes. The transport of the materials upon the overhead track is effected by means of an electrically driven trolley, equipped with a hoisting arrangement of simple design. This trolley can be constructed with either one or two jibs, within the range of which are the ship at the one extremity and the railway track at the other. The transporting capacity of the Benrath conveyers is considerable, varying between 80 and 100 tons of ore or coal per hour. It is a further advantage of this system that for the manipulation of the entire transporter only one operator is necessary. Moreover, after each lift that portion of the jib projecting over the ship is automatically drawn back, so that either the ship can be warped or the travelling bridge be moved along without the necessity of folding up any part of the bridge.

Section IV.

Electrically Driven Ore-Transporting Arrangements beneath the Ore Bins and the Electric Blast-Furnace Charger (Figs. 2, 3, and 4).

After the ores have been conveyed to the ore tipping ground or to the ore bins by means of the transporter previously described, it is an essential condition that the ore and coke should be transferred to the top of the blast-furnace with the least possible handling and cost of labour. For the performance of this work also electric energy is admirably adapted. Fig. 2 shows a charging apparatus in the design of which particular attention has been paid to the following points:—

(1) The whole of the mechanism is driven electrically.

(2) Hopper-shaped trolleys are provided to run beneath the ore bins.

(3) A single hoisting arrangement serves several blast-furnaces.

Parallel to the row of blast-furnaces are arranged the two ore and coal bins, which are filled direct by the ore transporter or from the railway cars on a track above them. Below these bins runs a hopper trolley, which can be filled from any one of the bins above it. A transfer car runs along parallel to the row of blast-furnaces, which conveys the hopper to the hoist, where it is tipped into the hoisting skip. This skip is attached to a trolley

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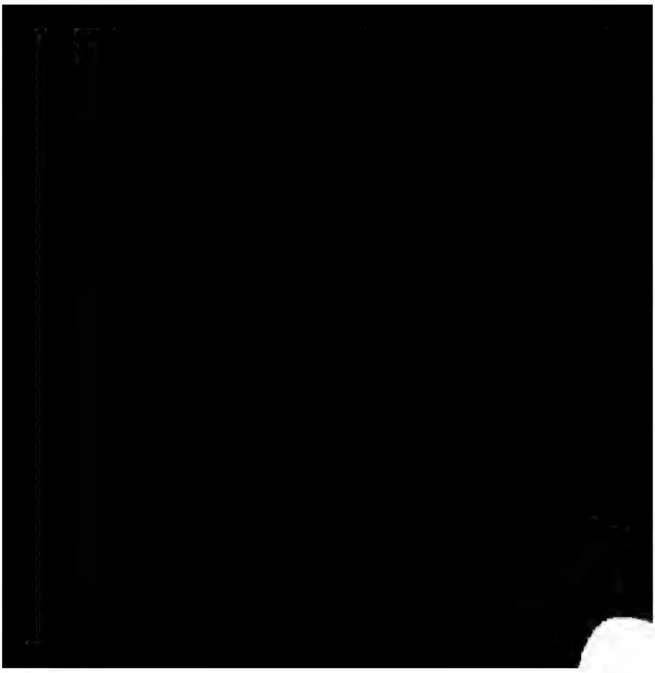

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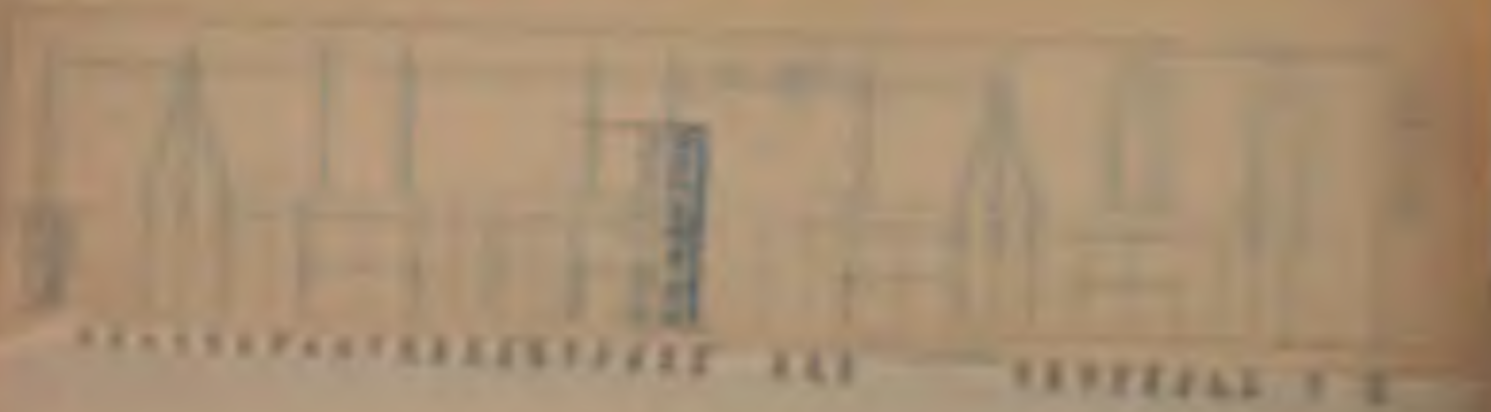

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same tongs and convey them to the soaking pits. After re-heating, they are extracted and carried by the same crane to the live rollers. An electrically driven soaking pit crane with automatic gripping tongs, with the raising and lowering of the ingots effected by means of a screwed spindle, and one operator only necessary for the service of the crane and manipulation of the tongs, has been in operation for several years at the Differdingen works, and from the time that it was first put into operation has worked admirably, dealing with the entire production of ingots made at these works.

In this connection might be mentioned the well-known charging machine for open-hearth and horizontal re-heating furnaces, by means of which considerable economy in power is secured, as well as in increased efficiency of the steelworks. These machines also bear further testimony to the advantage of applying electricity as a source of power in the steel-making industry.

Section X.

Electrical Appliance for Lifting the Soaking Pit Covers.

Among the more recent electrical appliances for iron and steel works may be mentioned the lever combination for raising the lids of soaking pits. By the adoption of this arrangement hydraulic cylinders, which are ordinarily used to carry away the covers of these pits, can be dispensed with. The apparatus is constructed to span one to three rows of soaking pits, and is able to serve a very large number of these.

Section XI.

Live Roller Driving Gear.

In the general construction of electric driving gear for live rollers, as usually carried out, two motors are used for the heavier roller trains for ingots or for long transporting trains of rollers. In other cases a simple driving gear with one motor is employed for standard roller trains of lighter construction. These trains of rollers are so well known that to describe them in detail here would be superfluous. It is only necessary to

illustrated in the present paper has the advantage, as compared with the American design, that the driving of the screw adjusting gear is effected by means of two motors, one on either side of the housing. Either motor can be cut out, or they can work together in the same manner as described in the earlier portion of the paper, by which means the speed of adjustment can be varied as desired. The system of two motors ensures, besides, a greater precision of action, and in case either motor is incapacitated from any cause, the other would still be sufficient to perform the necessary work of adjustment.

The upsetting and transferring gear is also electrically operated in many instances, and the hydraulic arrangements hitherto in vogue have been superseded. An electric ingot tilting cradle, shown in Fig. 10, is also of novel design, and has many advantages over the older hydraulically worked appliances hitherto used for placing the ingots upon the live roller table.

Section XIII.

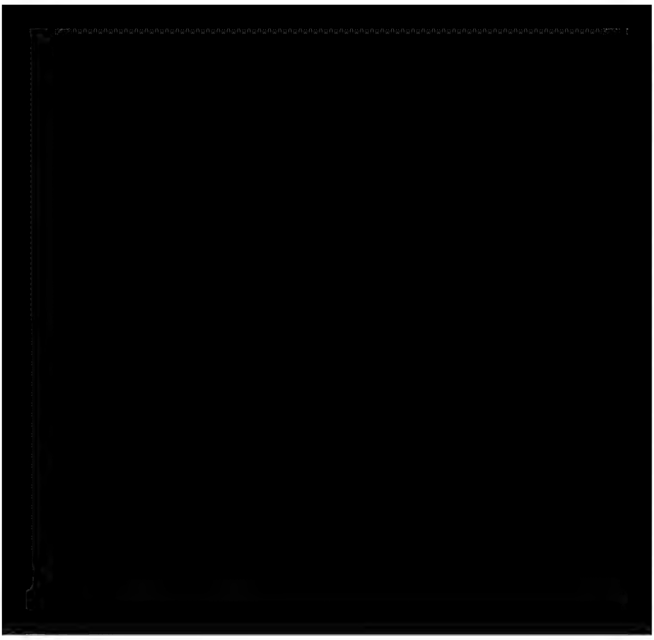
Electrically Driven Hot Saw.

For cutting the sections as they come from the finishing rolls various kinds of swinging saws have been invented driven by steam. In all these arrangements the advancement of the saw was always effected by means of the hydraulic cylinder. An electric counterbalanced hot saw is made intended to replace the hydraulic cylinder, the saw itself being also driven by an electric motor. With this hot saw girders of a depth of 550 millimetres (22 inches) can be cut. The diameter of the disc is 1500 millimetres (4 feet 11 inches), and the velocity at the periphery is 60 metres per second (198 feet). The power necessary for driving the saw is about 60 horse-power, and it is capable of making five cuts per minute.

Section XIV.

Adjustable Stop for Regulating the Length of Girders Cut by the Hot Saw.

This arrangement is exceedingly convenient for adjusting the length of the material when cutting the different sections



mill amounts to 35 tons of wire of 5 millimetres diameter in 10 hours. The driving of the rolling mill illustrated in Fig. 13 is effected by means of three motors. The initial outlay is therefore somewhat more considerable, but on the other hand a greatly increased output is secured.

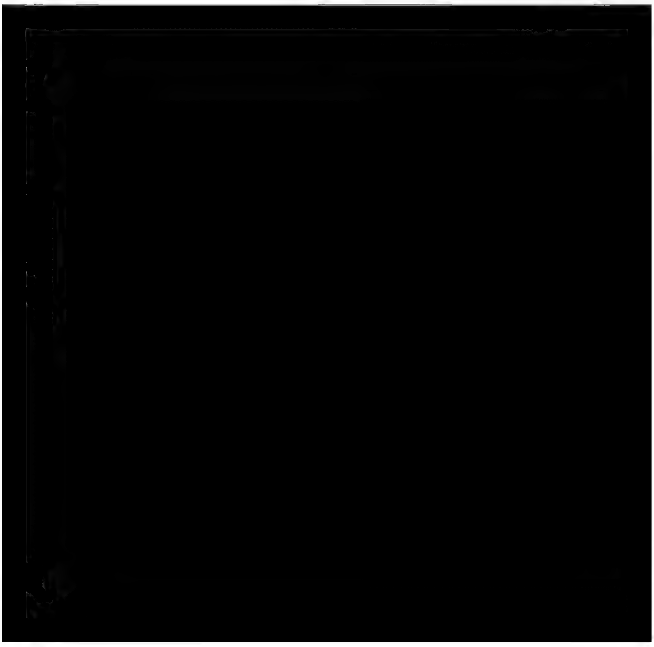
In general the following principle may be taken as applicable in the standard practice of electric driving in ironworks: that the motors should be of as nearly as possible the same power and type. By this means the cost of repair is lessened, and the changing of the working parts when worn out can be more easily effected.

SECTION XVII.

Before concluding this paper mention should be made of two appliances of special construction where a great advantage is secured if electric driving is adopted.

All works which are engaged in the manufacture of tires or of rolled discs have experienced the difficulty of producing a uniform thickness in the material of the tires and wheels when using rolls held up by hydraulic power. The material is often unevenly heated, and in consequence on account of the even pressure of the rolls an uneven thickness results in the colder parts of the rings. This defect is entirely overcome by means of the tire rolling mill shown in Fig. 14. The pressure on the rolls is maintained by means of two levers which are connected by a counterbalanced square threaded screwed spindle. This screwed spindle is driven by means of two motors which can be operated together or either can be cut out. The same method can be applied also to the manufacture of discs, where the two rolls which give the pressure are held up by means of a counterbalanced screwed spindle which is also driven by electric motors as above described.

In the stock-yard of a large ironworks it is also of considerable advantage to employ the system of cranes known as cantilever cranes, which traverse the whole length of the yard, and are so constructed that the projecting arms of the centre crane can just touch the outer extremities of the two outside cranes. By means of this arrangement the expensive structural ironwork



DISCUSSION.

Sir LOWTHIAN BELL, Bart., Past-President, wished to say a few words, and he would first direct his observations to the paper by Mr. Selby-Bigge. It had been recognised, of course, so frequently that, where you have a great distribution of power extending over a great area, electricity was certainly by far the best means of distributing that power, and therefore he need not take up their time upon that point. He would only call their attention to the fact that Mr. Selby-Bigge was entitled to their thanks for having reduced that to an ascertained fact, and had given figures in support of it, and for putting before them in very clear terms the amount of the saving. In that way they ought to look upon the contribution of this paper as a very valuable one in their transactions. In his own experience they had just finished putting up a very large rolling mill for the purpose of rolling large girders. A great deal of the work of the operation was driven by electricity. He might mention many other things that they had electric power for, which enabled them to change the rolls, the standards, and everything connected with them, in an incredibly short space of time, and he had little doubt that electric power would be largely appealed to for helping them in economising their production. Mr. Selby-Bigge had been employed by his own firm on many occasions, and anything that he put forward was entitled to their very serious consideration, and was deserving of every attention.

Professor SALOMONS (Berlin) said he fully agreed with the paper of Mr. Selby-Bigge, and appreciated most of his figures on producing electricity, and the savings which could be obtained. Ten or twelve years ago in Germany the electric motor was almost unknown in the factories, and was even looked upon with suspicion, because their mechanical engineers did not know it, and now they would find many thousands of motors with hundreds of thousands of horse-power; and in that very district of Düsseldorf there was no large plant without the dynamo

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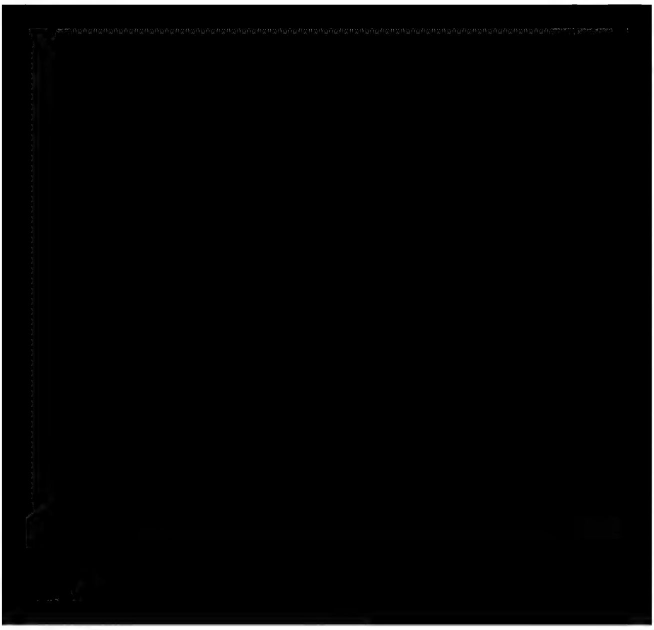
The last part of Mr. Selby-Bigge's paper, as to the scope and authority of the works manager, was of particular interest, inasmuch as it accounted for, in a very great manner, the lack of development along these lines in the United Kingdom, and the experience of the Westinghouse Company verified the author's statements.

On the other side of the Atlantic a works manager would go to his directors and outline the work that he purposed to carry out, and his report was more for their information than for their approval. Of course, if he should suggest in his report improvements that meant changes of too radical a nature which apparently did not seem justified, he would probably be asked to revise it. In a great many instances, however, the works manager would have already made arrangements for the execution of his policy before submitting it to the directors.

Mr. Stottner (of the German General Electric Company) said he should like to make a few remarks as to technical advice about electricity. There were no doubt great authorities on this subject in the United Kingdom, but they had also a great many whom he could not call otherwise than pirates in the electrical profession. From experience he knew of a good many cases where firms had been advised quite contrary to what was necessary; and if all the gentlemen present had as much knowledge of electricity as they had of the making of iron and steel, sometimes their hair would stand on end if they read the reports of pirate consulting engineers who were paid considerable fees for their advice. He did not go as far as Mr. Crompton did a few weeks ago, but he could not help saying as much as he had done. It was only natural that a firm with good experience and a good reputation should be much more able to give the best advice, and had certainly more at stake than one single man, unless he was an authority and had an enormous practice. It was true that the application of electrical transmission had not made the strides in England that it had in America and on the Continent. They had already, however, some substantial proof that it was being seriously considered, and if the British Government drove the whole Royal Arsenal at Woolwich electrically, and if Armstrong, Whitworth & Company, and Vickers



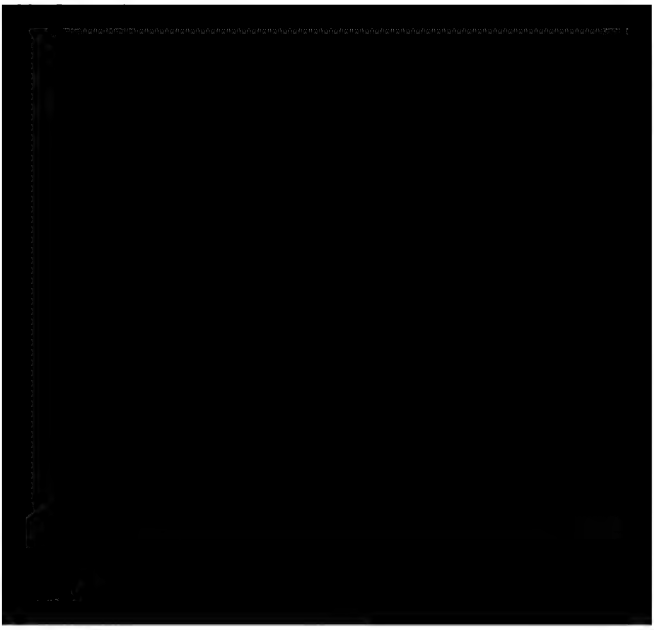
Siemens, in which the losses between the point of generation and that of application were given. It always appeared to his mind, and especially in papers of this kind read before the practical members of the Iron and Steel Institute, that when the cost of power was given it should rather be the cost at the point of application. The advantages of electric driving are thus much enhanced.

Thirdly, in the paper of Mr. Kylberg he noticed that no costs of working were given, and he supposed it must be assumed that the appliances named paid his clients, because the instances of electric driving were so numerous and varied. The paper was defective in this regard, because it was impossible to judge whether some of the machines described were applicable to conditions obtaining in Great Britain.

The gentleman who had just sat down had been good enough to throw stones at consulting engineers, perhaps with a great amount of reason; but he himself happened to be one of those questionably unfortunate individuals. But the last speaker did not seem to hit him (the speaker) very hard.

For instance, there was a case only a short time ago in which clients of his wanted power applied to their works for various purposes, and they adopted that unfortunate means of inviting a number of contractors to tender for the particular work. He had about twenty-seven of those tenders submitted to him by his clients for the purpose of advising as to which of those tenders he might really consider the best under the particular circumstances. Without going into details, he might say that it was quite impossible to select, so chaotic were the recommendations and prices. The matter ended in his clients adopting the course of procedure which should have been pursued in the first instance—that was, to order proper specifications to be drawn up by the consulting engineer in no way associated with any particular system or firm of manufacturers, and submit these to the most trustworthy contractors who had already tendered. Such was a much simpler and fairer method of procedure than putting a number of manufacturers and contractors to the expense of preparing the original tenders without a specification.

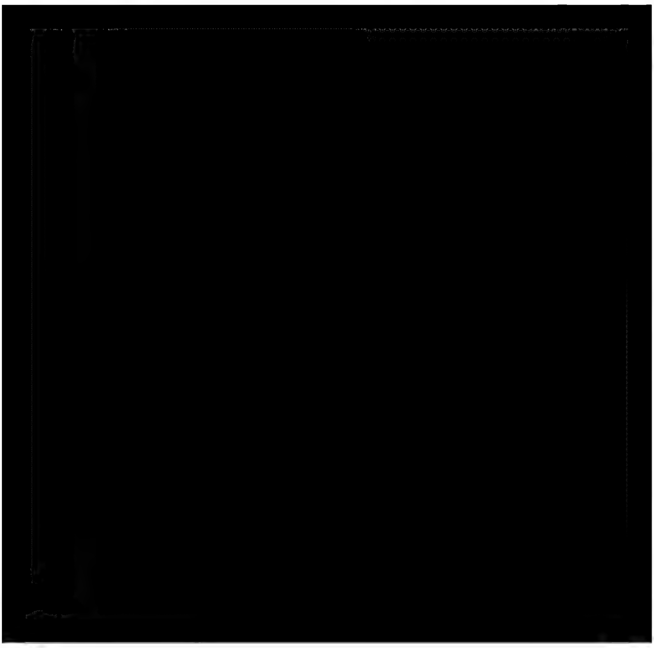
These two papers had dealt with the cost of transmitting power from one point to another. There was a very vital



superseded other kinds of motive power in cases wher transmission scheme had been well arranged. He ha had the opportunity of reading the paper, but it seem him that Mr. Selby-Bigge had been exceedingly fort in finding places where the transmission schemes had very bad indeed! There ought to be no difficulty in m an improvement in cases where there was a loss of 4(or 60 per cent. He himself should be the last man t down the application of electricity in any form; he was a believer in it, and sometimes its cost ought not to be take account, because they could do by electricity things which could not do by any other means. But in commerce firs and savings had to be considered, and he did not think Mr. Selby-Bigge allowed enough—he would not say for ciation, but for destruction of plant. His own experienc that all in a minute dynamos or motors went "Bang!" a cost money to repair or replace them. They had insurance panies to deal with, and they would not take the risk of for less than 7 or 8 per cent. of the initial cost, which was considerable amount. If their dynamos and motors did not down there might sometimes be a very large actual savin would Mr. Selby-Bigge kindly give some instances where transmission, as in a cotton mill, had been replaced by tricity, or where really good steam or shaft driving had superseded?

CORRESPONDENCE.

Mr. JOSEPH ADAMSON (Hyde) wrote that on looking the paper by Mr. Selby-Bigge it occurred to him tha figures given under the heading "Motor Tests" wou very much enhanced in value if further particulars as speed at which the work was done could be given. In as the figures now stood they were really quite useless alt apparently very valuable. This remark did not apply first portion of the paper, which seemed to give full infor in each of the various examples, although it was the first he had seen a calculation embodying the cost of keepin



Mr. WALTER DIXON (Glasgow) wrote that he had listened to the reading of the paper, and had since perused it, and he was sure that the Institute was indebted to Mr. Selby-Bigge for bringing the question again before them of the application of electric power to our manufacturing industries. As he stated, Mr. Selby-Bigge was one of the earliest in this field of industry, and since the time of his first papers, much work had been done by himself and others, and the experience in most cases would fall into line with the deductions brought out in the paper. With reference to the economies to be effected by the adoption of electric driving, while he (Mr. Dixon) had no disposition to criticise adversely the examples given, it must nevertheless be borne in mind—as the illustrations given showed—that these economies were largely effected by the simple process of installing the most modern systems in the place of the worst and obsolete forms of one of the older but still extremely important methods, viz. that of steam driving. In stating this, he was not detracting from the importance of the examples given, but the losing sight of these conditions had led to not a few disappointing results owing to electricity and electric motors having been applied in situations and under conditions where it was less adaptable from an economical point of view than other systems. Given a good modern up-to-date compact steam-driven works, electric driving must not be expected to show such results as were mentioned in the paper. Such establishments, however, with us were comparatively rare compared with the innumerable works where the old methods were still in use of low-pressure boilers, uneconomical engines, and distribution of power to small engines at greater or less distances from the steam boilers.

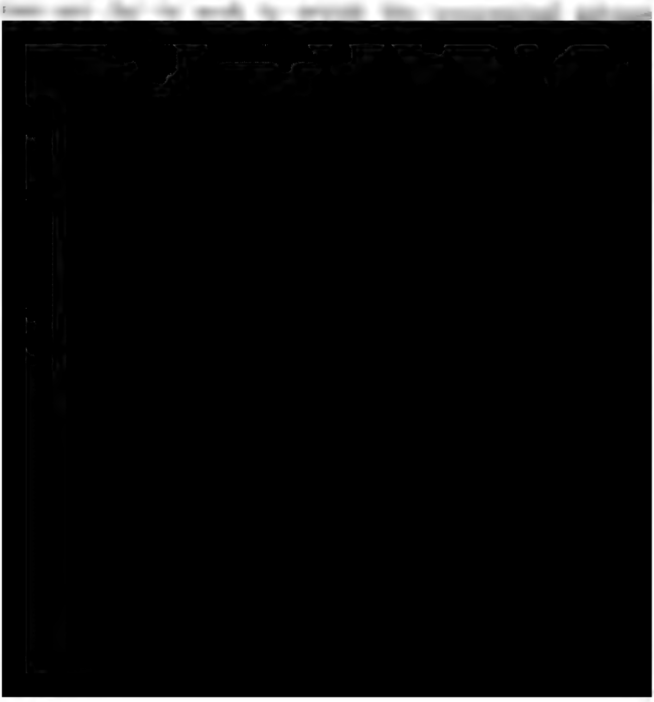
The re-modelling of such works with any kind of modern plant and modern methods would effect economies, and while it might be taken for granted that electricity was perhaps the most economical power to apply, in the experience of the writer, in each case the common-sense of the mechanical engineer, as well as the plausibility of the enthusiastic electrician could and should be applied if the best results were to be obtained. The writer, nevertheless, had not a few cases in his mind, and several of a most glaring kind, in which, in following the advice

plant, but this, after all, in progressive industrial concerns was not of serious moment.

He (Mr. Dixon) had several instances in his mind where it had been shown that it would be simply suicidal ever to contemplate the paying of anything like one penny per unit for the luxury of a power company supply. It was perhaps not necessary, but it would be a perfectly simple matter to show that these companies could not look to compete favourably for the electric supply to such works as most of the members were interested in.

The author had also referred to the question of the utilisation of blast-furnace gases. This was a subject in which he (Mr. Dixon) had interested himself since he took something to do with the first installation that had been laid down in this district, and, in fact, in Britain, by Mr. B. H. Thwaite, at the works of the Glasgow Iron and Steel Co., and he had since brought the subject forward on two occasions in papers read before the West of Scotland Iron and Steel Institute. The difficulties (until the last year or two) had certainly not been with the gases but with the obtaining of suitable gas engines. Fortunately, this difficulty—as might be seen, not only in the beautiful exhibition, but also in the various works on the Continent—was now overcome, and their utilisation on a large scale would be accomplished in the near future. In Germany and America, more so than in this country, and especially in Scotland, these blast-furnaces were in more or less proximity to steel and other works, so that there was ample outlet for the spare power. In Scotland, however, many of the blast-furnaces were isolated, and unless an outlet outside themselves could be provided, there seemed little opportunity for the utilisation of the gases in the way suggested.

There was an aversion on the part of the blast-furnace proprietors to bind themselves to supply power to outside users, and though there were some instances of spare gases being used for the manufacture of calcium carbide and other products, it had been found, here at least, that the "shoemaker prefers to stick to his last." One important result which the development of these gas-engines would effect, probably equally or more important even than the utilisation of blast-furnace gases, would be the use of producer gases for power purposes where hitherto steam had

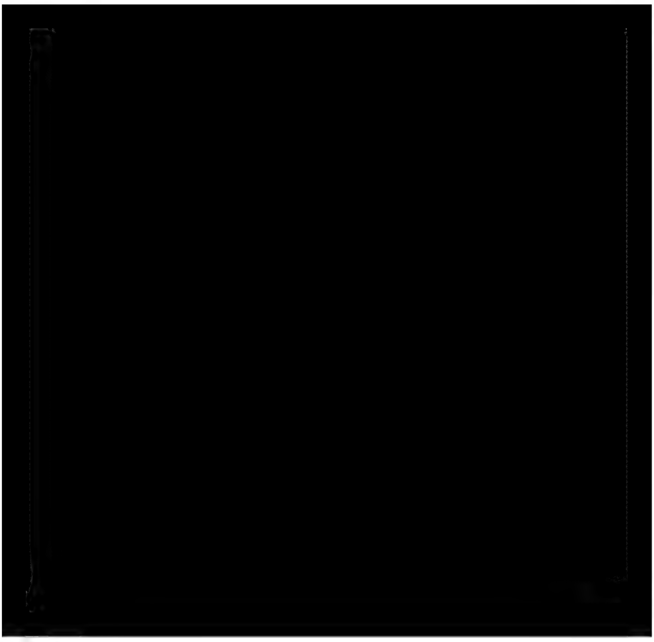


of the dim and doubtful future to recoup. This might be t *raison d'être* of what Mr. Selby-Bigge styled "the etern question," viz., what is the cost going to be, and the "pigeo holing" to which he referred.

As a result of personal observations, he (Mr. Dixon) stat in a paper read before the West of Scotland Iron and Steel I stitute, that the industries of America appeared to him to be ve largely in the hands of men under thirty-five years of age, a while there were instances to the contrary, he still saw no reas to abandon this idea. He was glad to see what he took to a confirmation of this in Mr. Selby-Bigge's remarks as to t function of the American works' managers. There was lit doubt that in America the elder directors of companies look for a lead from their works' managers, who were usually you men; how far this was so in this country each of them wou decide from their own experience and that of their friends. one American tersely put it, "they considered the intuitions young men to be quite as reliable as the experience of the eld ones," with the additional merit "that you get there mu quicker."

In making this criticism he (Mr. Dixon) would like express his unmeasured thanks for the admirable and suggesti paper.

Mr. D. B. Morison (Hartlepool) considered that Mr. Selb Bigge's contribution to electric power literature was especial valuable in that it contained data which had been compiled wi evident care, and might be relied upon for general accura The plant at the Hartlepool engine-works was referred to the paper. In 1896 Messrs. T. Richardson & Sons availed them selves of Mr. Selby-Bigge's professional services with a view driving their entire works electrically. The scheme he submitt was approved, and the work was carried out by him in i entirety, with the result that in 1897 electric motors had replac steam-engines in every department. The proposition was u doubtedly one to show good results, as the works had been built during a period of fifty years. There were dozens of overload steam-engines, thousands of feet of steam pipes, and various desig of boilers—a wasteful combination, but not a whit worse th



interest on capital. He was glad to see that Mr. Selby-Big had touched upon the question of using blast-furnace gas generating elecricity, and as his firm had recently taken up t manufacture of large gas-engines for this purpose, he had h occasion to investigate the subject, and could give his assuran that the statements made in the paper were not by any mea exaggerated.

Mr. SELBY-BIGGE, in replying to the discussion, said he h first of all to thank the President and Sir Lowthian Bell for t kind and too flattering remarks they had been good enough make upon the paper he had contributed to the Institute.

It had been his object from the outset to collect and la before them data of an essentially practical nature, particularl with regard to the cost of production of electricity, and th actual savings which would accrue to works owners by it superseding the older methods of driving at present in vogu in the great majority of works in our country.

It might be said that this was a somewhat new departure and that the paper dealt more with the commercial side of th aspect than the purely technical, but, after all, was not this th kind of information that was of most use, the want of which had been so often felt by directors, works managers, and engineers in enabling them to decide upon improvement schemes for their different works? He was very glad to find that throughout the discussion no adverse criticism had been expressed on this point, and he thanked them for their appreciation of his efforts in this direction. He was glad to see that the views of Professor Salomons and the experience of German engineers coincided with his own; the magnificent exhibit of the Lahmeyer Company at the Düsseldorf Exhibition in electric power applications, as well as those of other German firms, showed to what an extent electric power work had advanced in Germany, and particularly so in regard to mining and works equipment.

The views expressed by Mr. Oliver Shiras, of the British Westinghouse Company, would generally represent American opinion on the subject, and it was very gratifying to the author to hear that the views he had taken with regard to one of the

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advantages which electricity to-day placed in their way, prise and progress in this country would be greatly stimul

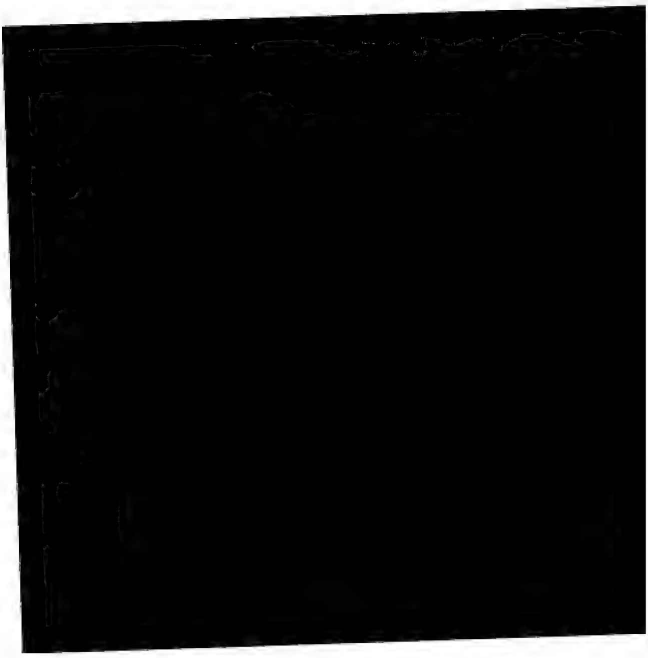
In his brief remarks Mr. J. F. Robinson, of Messrs. Stewart & Co., raised a very important point, viz. the inc regularity of speed in machine shop driving. Under fluctuating loads upon the line shafts the motors mainta constant speed which was rarely attained in the case o shafts driven by separate engines; this regularity of speed very beneficial effect on the work going on throughout the

In his remarks Mr. T. Westgarth had confirmed b own experience the statements put forth by the auth to the cost of production by works' owners themselves less than ½d. per Board of Trade unit, and his referen blast-furnace gas engines confirmed the figures given i paper.

Having now dealt with the various points raised i discussion, the author trusted that this paper might pro practical service to those interested in the matter, that it serve as a guide to those contemplating electric power ap tions, and as an incentive, to those who had not yet s the subject, to investigate the possibilities of the s thoroughly.

Mr. Kylberg wrote, in reply to Mr. Vaughan Hughes' in that his aim had been from the beginning to treat the sub the paper from the standpoint of the designing and constr engineer. The illustrations submitted would render this and he hoped at an early date to be able to bring befo Institute a continuation of his paper which would dea clusively with the efficiency in practice, the working exp and the cost of installing the various machines, based o tonnage of the output of an entire plant.

He was somewhat surprised that Mr. Vaughan Hughes s ask whether some of the machines described were applica conditions obtaining in Great Britain, and he would only r him that long ago the fact was realised that the rapid handl mechanical means was one of the chief factors which lo the cost of production, and thus directly affected the pri the finished products.



RESULTS OBTAINED IN EQUALISING THE TEMPERATURE OF HOT BLAST.

By LAWRENCE F. GJERS AND JOSEPH H. HARRISON, M.Inst.C.E., Middlesbrough.

It will be remembered that the authors read before the Institute, in May 1900, a short paper describing an apparatus for converting hot blast of that irregular temperature which is unavoidable when using regenerative stoves, into hot blast of regular temperature, for use in blast-furnaces, with a view to obtaining greater regularity in furnace working, and in quality of iron produced.

At that time there was not an equaliser at work, but one was being erected at the Normanby Ironworks, Middlesbrough, in connection with a new furnace. This was put to work on May 6, 1901, and has worked continuously from that date, without having once been stopped, and without having cost a penny in either repairs or attention of any kind, and by the permission of the Normanby Ironworks Co., Ltd., the authors are enabled to submit the results obtained in the equalisation of the temperature of the hot blast for this furnace.

The equaliser is much the same shape as a Cowper stove, 20 feet diameter by 55 feet high, built of steel plates, and lined with fire-brick. A central division wall from the bottom to near the dome, divides it into two similar sections, which are filled with fire-brick chequer work.

The hot blast of irregular temperature as it leaves the stoves is made to enter at the bottom of one of these sections. It passes up through the chequer work of that section and down through that of the other section, and is passed out at the bottom at a perfectly uniform temperature. It is then carried to the furnace by suitable connections.

The excessive heat of the blast given by a stove which has just been put on blast after heating up, when it enters the equaliser, comes at once in contact with the chequer work of the inlet section, which has been partially cooled down by the re-

III. (Plates XXIII. and XXIV.) show true enlargements of some of these records, which were kindly lent by the Normanby Ironworks Co. in June last.

Diagram II. shows a pair of twenty-four-hour records for 30th May 1902, taken under normal conditions, the blast not having been off at all except at casting times.

The upper record shows the varying temperature of the blast entering the equaliser from the stoves, and the lower one shows the uniform temperature of the same blast as it leaves the equaliser and goes to the furnace. It will be noticed that the "equalised" record is almost a perfect straight line, except for the gaps when the blast was shut off the furnace at casting times. It will also be noticed, in looking at the unequalised record, that in some cases, where a freshly heated stove has gone on, the blast temperature has jumped up more than 200° F. in a moment, but on following the same time line on to the equalised record below, not the slightest variation is found in the temperature of the blast going to the furnace. This is a most severe test of the application of the principle upon which the apparatus is based, and no doubt you will agree that the results are highly satisfactory.

Diagram III. shows another pair of twenty-four-hour records for 12th June 1902, and which are very interesting as showing how the equaliser acts as a sort of "heat-buffer" between the stoves and the furnace in case of sudden and excessive rise of temperature of the hot blast from the stoves, and also as a heat reservoir.

This pair of records extends from midnight on 11th June to midnight on 12th June. About six o'clock on the evening of the 11th it was found necessary to stop the engine blowing this furnace for two or three days, and the furnace had to be coupled up to a common hot-blast main, serving two other furnaces with blast at a much lower pressure.

The result of this was that a much less weight of blast was passed through the stoves per minute, and consequently the temperature of the blast given by them went up by leaps, as shown by the upper record. But, on looking at the equalised record below, it will be seen that the equaliser had the effect of checking this rapid rise of temperature, and allowed it to take place gradually over the twenty-four hours.

On comparing this system with that of levelling, or reducing the hot-blast temperature to the minimum temperature given off by the stoves, by the admission of cold blast, for the purpose of regularity, so largely adopted in America, and to a less extent in this country, it will be seen how very much easier the one is to

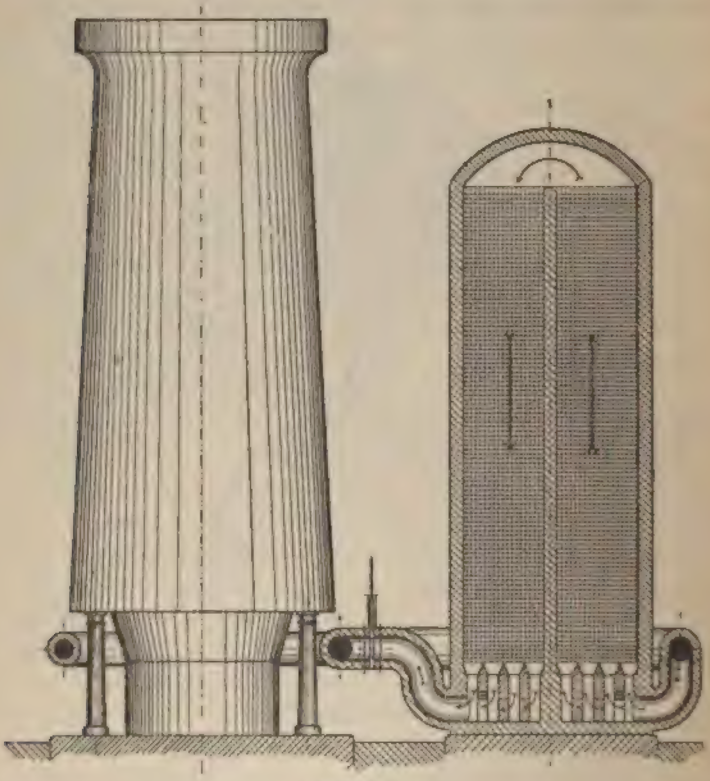


DIAGRAM IA.

work than the other. In one case the stoveman has to be continually shutting off a little cold blast every few minutes during the run of a stove, and when that stove goes off and another on, he has to open out the cold-blast valve again until he finds by his pyrometer he has got the temperature he is ordered to keep, and then he begins to go through the same gradual shutting-off of the cold blast as before, and so on night and day.

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PROBABLE EXISTENCE OF A NEW CARBIDE OF IRON, Fe_2C.

By E. D. CAMPBELL and M. B. KENNEDY, Chemical Laboratory of the University of Michigan.

The only well-recognised carbide of iron which has been recovered from specimens of commercial iron or steel is that which was first described by Sir F. Abel and Mr. Deering in 1885. This carbide, according to their figures, is represented by the formula Fe_3C. Abel and Deering's work has been repeated since, with various modifications and improvements in method, by Müller,† Osmond and Werth,‡ Arnold and Read,§ and by one of the present authors.|| The results obtained by all these experimenters confirm the conclusion drawn from the work of Sir F. Abel, that the greater part of the carbon in annealed steel exists in the form of a definite carbide having the empirical formula Fe_3C. The carbide obtained by all the authors mentioned has been recovered from steel containing, in most cases, less than 1 per cent. of carbon. Perhaps the most exhaustive research is that of Arnold and Read, who show that, even in carefully annealed steel, only about 72–94·9 per cent. of the total carbon in the metal is recovered in the form of carbide. The failure to recover all of the carbon as pure carbide seems to be due to the decomposition of carbide of iron, not crystallised or precipitated, but remaining in solid solution. As might be expected, carbide of iron, held in solid solution in the iron, would be much more easily decomposed by the action of dilute acids than if the carbide were precipitated or crystallised in masses of appreciable size. If we consider the conditions under which the carbide recovered by Arnold and Read was formed, we may readily account for the failure to recover the total carbon of the

* *Proceedings of the Institution of Mechanical Engineers*, 1885, p. 30.
† *Stahl und Eisen*, vol. v. pp. 179–184.
‡ *Annales des Mines*, 1885, vol. viii. pp. 5–83.
§ *Journal of the Chemical Society*, 1894, vol. lxv. p. 788.
|| *American Chemical Journal*, 1896, vol. xviii. p. 836.

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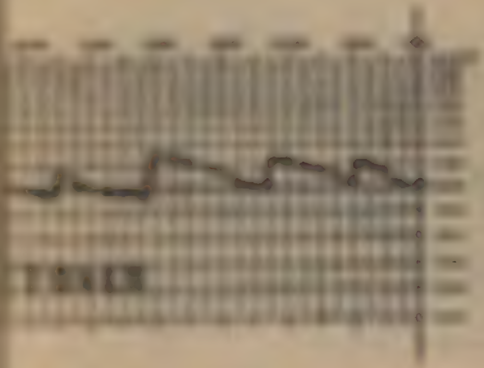


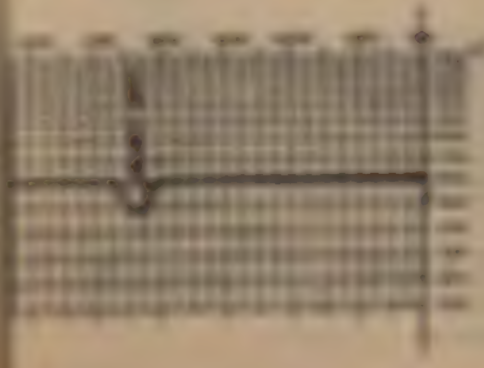
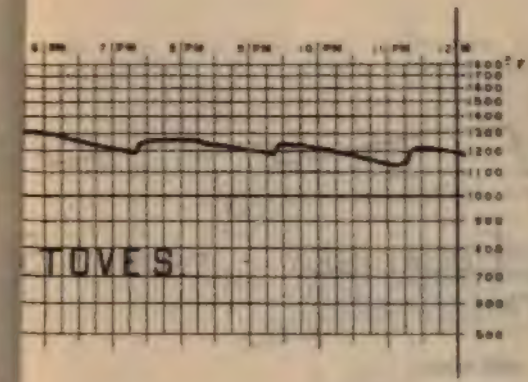


PLATE XXIV.

LISER.

TER.

T TO GO TO FURNACE.



TOVES.

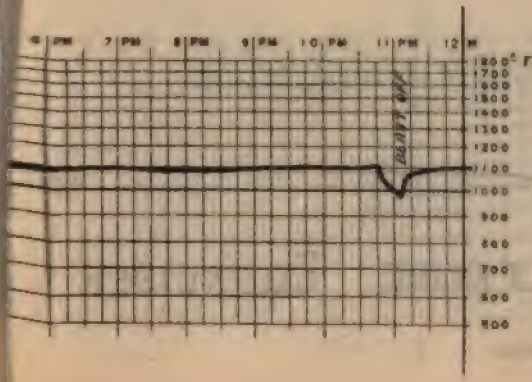
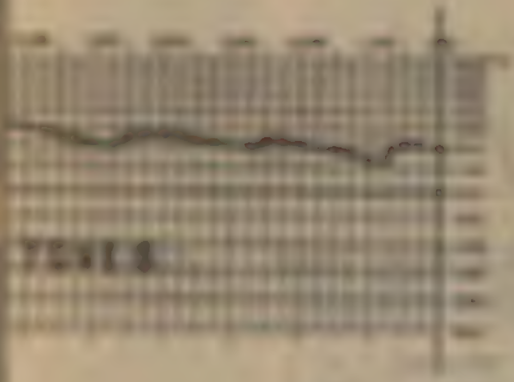


Plate [illegible]

LISER



TERS

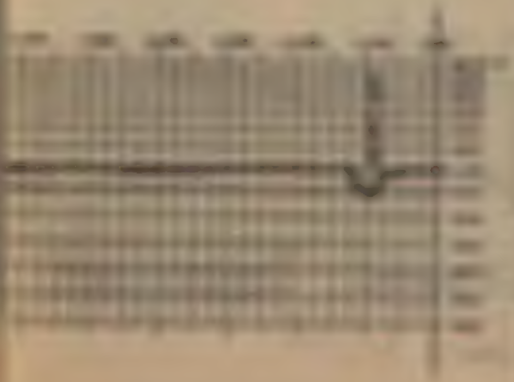
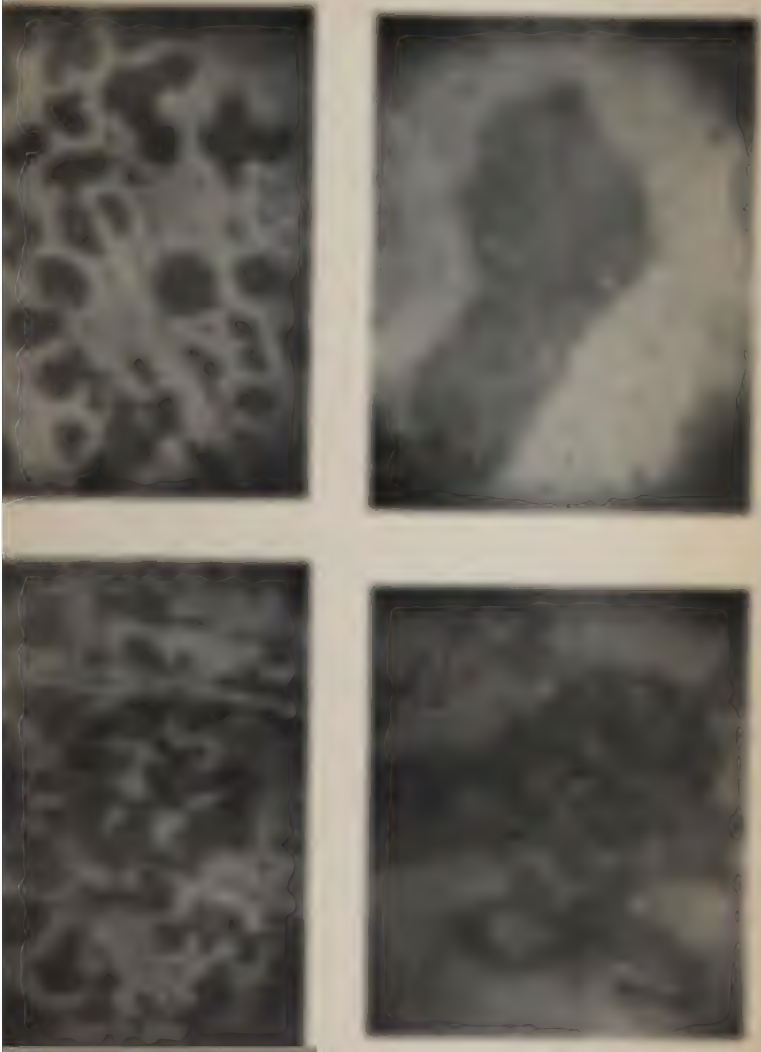
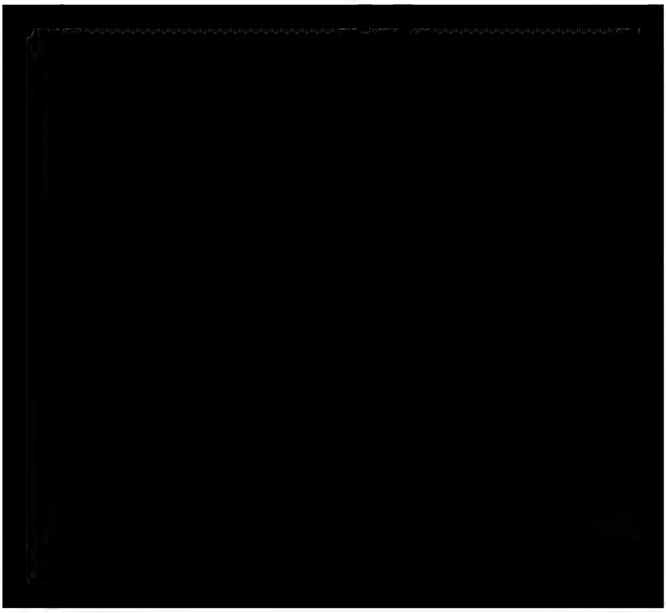


PLATE XXV





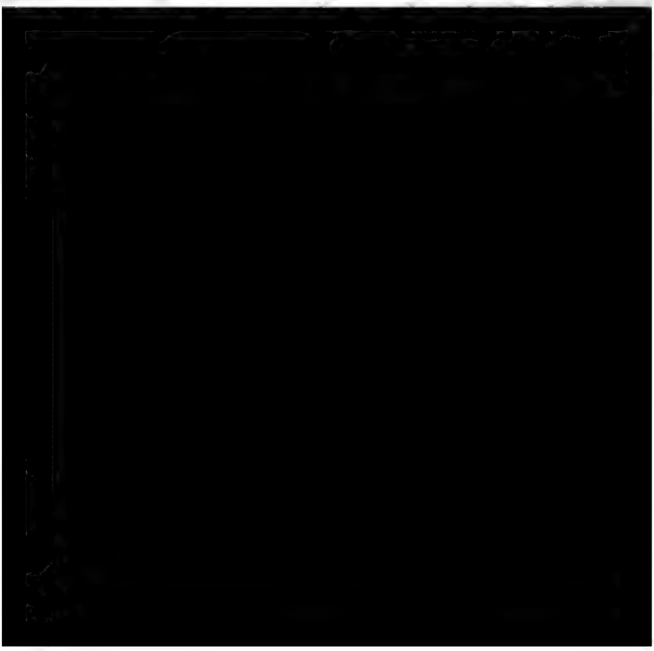
different composition. In order to decide this question, we have isolated the carbide from a sample of annealed white iron. The iron employed for this purpose was a pig of white charcoal iron, furnished us through the courtesy of Mr. L. E. Dunham, manager of the Ashland Iron and Steel Company, Ashland, Wisconsin. The original iron had the following composition: combined carbon, 3·53 per cent.; graphitic carbon, 0·01 per cent.; silicon, 0·07 per cent.; phosphorus, 0·13 per cent.; sulphur, 0·01 per cent.; and manganese, 0·05 per cent. The pig was broken up, and a piece weighing about 900 grams selected for the work. This piece was first dressed with an emery wheel until perfectly bright, and was then placed in a porcelain evaporating dish, covered in turn with a second dish, so arranged that a stream of hydrogen could be kept up during the annealing. The temperature to which the piece was raised was measured by means of a Le Chatelier thermo-couple placed close to the iron. The dishes containing the iron were placed in an assay furnace, and the temperature gradually raised during a period of five hours to 950° C. After maintaining the iron at a temperature varying from 930°–950° C. for about two hours, the temperature was allowed to fall, about three hours being required for it to reach 600°. An analysis of the iron so annealed showed that the graphitic carbon had increased only to 0·12 per cent. This piece of annealed metal, supported by means of a heavy copper wire, was connected with the anode of a storage battery, the cathodes, one on each side of the bar, being platinum cylinders. The solution used as an electrolyte was fourth-normal sulphuric acid, about three-fourths of the iron being immersed during the electrolysis, which was conducted in a large beaker containing about four litres. In the electrolysis, an electromotive force of two volts and a current of 0·30 ampere was found to give the most satisfactory results. When such a current as this had acted for twenty-four hours, the iron was taken down and the adhering carbide rubbed loose under water by means of a brush made of very fine aluminium wire, such as employed by one of us in the recovery of pure carbide of iron, referred to in the first part of this article. When the carbide had been removed, fresh acid was placed in the beaker and the electrolysis continued. The recovered carbide was first triturated lightly under water and

due to the irregular dissolving away of the iron during the different electrolyses. Some days a small yield of carbide would be obtained in proportion to the weight of metal dissolved, and perhaps the next day a comparatively large layer of carbide would be removed. At the end of all the work the piece of iron was found to be covered with a rather firmly adhering, but porous layer, which could be scraped off to a depth of nearly a millimetre, if considerable pressure was applied. This was not, however, included in the above table. The carbides recovered had in general a grey metallic appearance when examined in mass with the naked eye, some samples being brighter than others. Under the microscope it appears, as would be expected from a substance precipitating or crystallising from solid solution, "an amorphous black powder, without apparent crystalline form." Sample No. 22, when first recovered, seemed to be the brightest of any, and was kept separate for this reason before an analysis of it was made. These carbides were all in the form of a powder fine enough to easily pass a sieve with 100 meshes to the linear inch, but a considerable portion would be retained by a 200 mesh sieve. Three of the samples of the carbide were separated by means of a 200 mesh sieve into two portions, coarse and fine. The results of these separations, with the analyses of the separated portions, are given in the following table:—

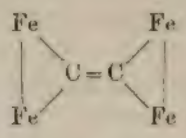
TABLE II.

Sample.	Per Cent. Coarse.	Per Cent. Fine.	Carbon in Coarse.	Carbon in Fine.
7-8-9	36·01	63·99	7·51	9·31
20-21	52·76	47·24	6·94	8·80
22	38·46	61·54	8·76	9·87

A determination of the graphitic carbon in the fine material from sample 22 gave only 0·12 per cent. Those samples containing the highest per cent. of carbon do not seem to have been decomposed by the acid in the process of recovery to any greater extent than the samples with the lower per cent. of carbon. This fact, taken together with the fact that all the samples wer



relation to the carbon atoms as they bore in the original ferro-carbon. Such a carbide would have a general formula $(Fe_2C)_n$, and the structure of the derivative from the above member would be—

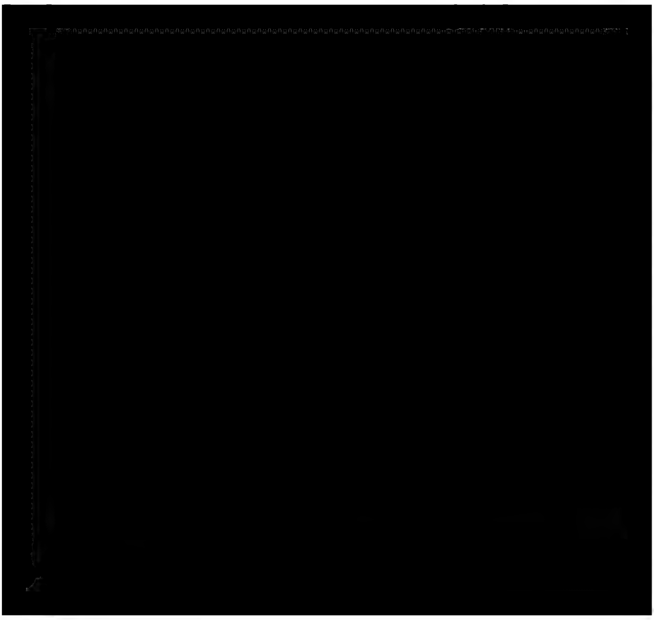


Carbides of the general formula $(Fe_2C)_n$ derived in this way from carbides of the general formula $(Fe_3C)_n$ would give the same products of solution in acids. The fact that $(Fe_2C)_n$ is recovered only from iron containing a large percentage of carbon, while $(Fe_3C)_n$ is the only product from annealed steels, would be very strong evidence that the $(Fe_2C)_n$ is precipitated or crystallised as such from solid solution during slow cooling and is not derived as a decomposition product of $(Fe_3C)_n$. Whether $(Fe_2C)_n$ is a constituent of the pearlite or of the free cementite in slowly cooled white iron, we are at present unable to say.

A mixture of carbides $(Fe_3C)_n$ and $(Fe_2C)_n$ to contain 8·20 per cent. carbon and 91·80 per cent. iron, would have to be made up of 49 per cent. of the former and 51 per cent. of the latter carbide. If all the carbon and iron recovered as carbide described in Table I. represents a mixture of the two carbides recovered from 302·05 grams of metal, there would be 17·03 per cent. of $(Fe_3C)_n$ and 17·73 per cent. of $(Fe_2C)_n$, or in all 34·76 per cent. of mixed carbides derived from the electrolytic treatment of slowly cooled white iron.

When pieces of the same white iron employed in the above-described work were electrolysed without first annealing the iron, samples of carbide were recovered containing in many cases much more carbon than was found in the carbides recovered from the annealed metal. In the case of the carbides recovered from the unannealed metal, the sum of the iron and carbon was far short of 100 per cent., and the difference increased as the percentage of carbon in the residues increased, thus showing that the large amount of carbon was due to decomposition.

It was thought that possibly a microscopic examination of the white iron, before and after annealing, might throw some



CORRESPONDENCE.

Mr. E. H. SANITER (Middlesbrough) wrote that the authors seemed to have overlooked his work in connection with Fe_3C.* If they had referred to it, they would have found that it was possible to obtain an almost theoretical yield of Fe_3C, viz. 96·5 per cent., considering that this was washed by decantation and some thereby lost. Their yield appeared to him to have been low because they did not include the porous layer alluded to in their yield of carbide, though it undoubtedly would be carbide, and they had also omitted to deduct the graphite. Under these circumstances it seemed hardly necessary to formulate the theory, that part of the carbide remained dissolved in the ferrite, to account for the low yield. The authors also remarked that the carbide "appears under the microscope to be an amorphous black powder, as might be expected from a body precipitating from a solid solution." Now he thought it was not a fact that the whole of the cementite formed by 3·5 per cent. of carbon precipitated from solid solution, and, further, it seemed very remarkable that the cementite should be disintegrated to such a fine state of division when it occurred in such large masses as shown in the micrograph. If the order were considered in which the carbide as cementite and pearlite precipitated it would be at once recognised that the cementite precipitated first from the richest solution of carbon, and that the Fe_2C, if such a body existed, should therefore be contained in the cementite carbide, and not in the pearlite carbide, and as the cementite carbide was the coarser, one would expect to find the higher carbon in the coarser particles; but in Table II. the reverse was the case. As the finer portion was naturally the more decomposed, this led one to suppose that the high carbon was due to carbon hydrate. It would throw light on this point if the authors would give the amount of iron in the coarse and fine portions. It was stated in the writer's paper on "Carbon and Iron," already referred to, that it was noticed that the coarser particles of carbide were very

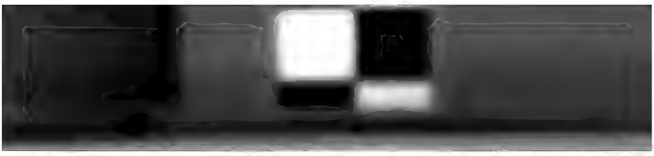
* *Journal of the Iron and Steel Institute*, 1897, No. II., p. 115.

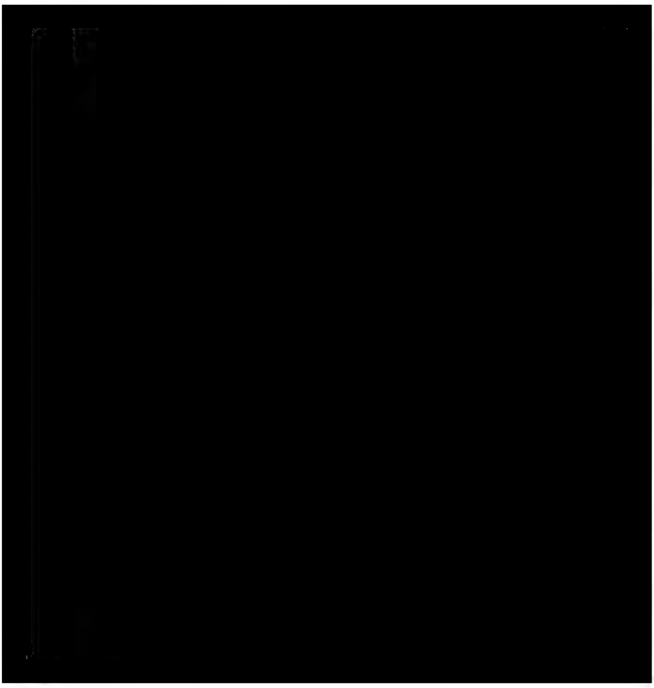
Table I. Corrected for Constant Error of 1 *per cent., a Arranged in Order of Increasing Difference of* 100 − (*Iron Carbon*):—

Recovery.	Iron Percentage.	Carbon Percentage.	Not Accounted for Percentage.	Total.
4-5 6	93·52	6·46	·02	100
1 2 3	92·97	6·47	·56	100
13 14	92·19	7·00	·81	100
10 11-12	91·38	6·93	1·69	100
23 24	90·12	7·88	2·00	100
15 16	90·17	7·79	2·04	100
7 8 9	89·33	8·60	2·07	100
22	88·51	9·36	2·13	100
17 18 19	89·3	8·41	2·29	100
20 21	89 19	7·65	3·16	100
Coarse Fe_3C from 1 per cent. cement bar (Saniter) .	89·9	7·23	2·87	100

There it would be seen, with some irregularities, that as t "not accounted for" portion increased, so did the carbon, whi was just what might have been expected if carbon hydrate we present. In conclusion, while not denying the possible existen of Fe_2C, he considered the evidence brought forward by t authors was insufficient to establish their case.

The Authors, in reply to Mr. E. H. Saniter, regretted that th had overlooked his valuable paper, which would have made the place the figure 96·5 per cent. instead of 94·9 per cent. as t proportion of carbon from moderately high carbon annealed ste recoverable by electrolysis in acid solution in the form of carbi Their assumption that complete recovery of the carbon as carbi was probably not possible under these conditions was based n upon their own work, but upon the results obtained by othe especially Arnold and Read, as well as those of Mr. Sanit himself. Microscopists were agreed that the colour produc in martensite by the action of iodine or nitric acid was due carbon either in solution as the element, or some carbon co pound. Arnold and Read had shown that only a portion of t carbon existing in solid solution as martensite was recovera





fine portions of sample 22 had been determined. This was done at the time, but the amounts were not reported in their table. The results were as follows: coarse—carbon 8·76 per cent., iron 89·79 per cent., unaccounted 1·45 per cent.; fine—carbon 9·87 per cent., iron 88·42 per cent., unaccounted 1·71 per cent. It would be seen that the unaccounted had increased over what it was in the original material when first analysed, at which time it was 1·15 per cent. This was easily accounted for by the probable oxidation of the material during the several weeks that elapsed between the analysis of the original sample and the portions separated by sifting. The greater proportion of unaccounted in the fine as compared with the coarse was probably rather due to its more rapid oxidation on account of its finer state of division than to decomposition at the time of isolation. It should be borne in mind, in considering these figures, that all the samples of carbide in their work were triturated under water so as to separate any carbonaceous matter, and were then washed by decantation until the washings came over perfectly clear; and also that sample 22 was selected on account of its exceptionally clean metallic appearance before any analyses were made.

From his first rearranged table, Mr. Saniter drew the general conclusion that the greater the yield of carbide the higher the percentage of carbon in the carbide, and therefore that the increased percentage of carbon was due to the decomposition of the carbide by long exposure to the acid. He admitted that there were some exceptions, and if the table was examined it would be noted that, out of nine cases, five followed his rule and four were exceptions. With so many and so marked exceptions they did not see how Mr. Saniter was justified in his conclusions. Again, they did not feel that Mr. Saniter had good ground for assuming a constant error of 1 per cent. If they were to admit such an assumption, and examined his rearranged second table, it would be noticed that, out of ten samples, six only followed his general rule and four were exceptions. While not claiming that the existence of a carbide Fe_2C was proved by the work described in their table, they did not feel that Mr. Saniter's arguments had appreciably diminished the probability of such a carbide. They trusted that some other

and for the manner of their discussion in that room, he believed he might claim for it the position of one of the highest merit since the Institute was launched. He therefore supported, and did so most cordially and honestly, the motion which was then placed before them for their reception.

The motion was enthusiastically carried.

Mr. R. M. DAELEN said it was his pleasant duty to propose a hearty vote of thanks to their President, Mr. Whitwell, for his conduct in the chair. He took that opportunity of congratulating him on the large attendance, and on the large amount of business got through under his guidance. He must say, on behalf of the Reception Committee, that they especially were grateful to the President for his help in rendering the meeting so successful, and they hoped that the other portions of the proceedings would be equally successful.

Mr. E. SCHRÖDTER, in seconding the vote of thanks, said that Mr. William Whitwell, the President, had in the two days not only been their President and master-guide, but that he had gained all their hearts by his very kind manner. At the same time he would take the opportunity of expressing his sincere gratitude to them for the vote of thanks which referred specially to himself, and for the very kind words of Professor Howe. He begged them to accept his sincere thanks.

The PRESIDENT, in acknowledging the vote of thanks, referred to the magnificent success of the Exhibition, and congratulated the city of Düsseldorf and the district on the immense success which had attended it.

The proceedings then terminated.

VISITS AND EXCURSIONS AT THE DÜSSELDORF MEETING

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It would be very difficult adequately to express the visitors' appreciation of the excellence of the arrangements made by this Committee, and of the hearty manner in which the members were welcomed.

The proceedings on September 3 began with great punctuality, and the Council had every reason to be satisfied with the support they received from the members, as evinced by the large attendance. On the second day, the great hall of the Tonhalle was again well filled. During the afternoons of September 3 and 4 the Exhibition was visited, where groups were formed under the guidance of experts for the purpose of examining the various sections of metallurgy, mining and machinery.

The Conversazione in the Tonhalle.

On Wednesday evening, September 3, the Mayor and Corporation of the City of Düsseldorf gave an entertainment to the members of the Institute and the ladies accompanying them in the Tonhalle, the great hall of which, known as the *Kaisersaal*, was brightly decked for the occasion with flags and with festoons of green and flowers. The guests were received by Mr. Ludwig Feistel, the Mayor, and the principal event of the evening was an excellent concert, solos being splendidly sung by Frau von Hübbenet, who is the Prima Donna of the Düsseldorf Municipal Theatre. The English members were also much delighted to hear the folk-songs rendered by the Düsseldorf Male Voice Choir under the direction of Mr. Kramm. This society is composed entirely of local gentlemen, and among its members who contributed to the entertainment of the visitors was Mr. Lemke, who during the day had devoted himself in the temporary office of the Institute at the Tonhalle to the task of acting as honorary interpreter. The Municipal Orchestra was under the direction of Mr. Adorjan. At the close of the concert (which lasted an hour) light refreshments were served in the *Rittersaal*.

In addition to this delightful entertainment, the Corporation of Düsseldorf conferred a further kindness on the members by presenting each with a handsomely bound artistic souvenir volume of 246 pages, written by Dr H. Meydenbauer, and profusely illustrated, describing the city of Düsseldorf in the Exhibition year 1902.

upholder of peace, their dutiful greeting.—(Signed) Wm. Whitwell, President." * He said without further remarks he would ask them to join with him in drinking long life and happiness to their two great rulers, the German Emperor and the British King.

Sir James Kitson, Bart., M.P., Past-President, in proposing "The Guests," said that twelve years ago the representatives of the Iron and Steel Institute paid a memorable visit to the United States of America, and they paid that visit in association with the Verein deutscher Eisenhüttenleute, the members of that Institution being then presided over by their lamented friend, Mr. Thielen (Vice-President of the Institute), whose loss they all deeply deplored. In the United States of America were English and Germans who marched side by side in endeavouring to instruct themselves for the advantage of their industries in the great progress which was then being made in the States. They had now come back to visit their German friends to see what advantage they had taken of that experience, and he ventured to say that the English members were astonished at the remarkable development which had been made by them in all the branches of the iron and steel manufacture, and particularly in their scientific application of the new power of electricity. The English members did not venture to say that we would rival them in our Britannic developments, but he would say that if the Germans would come to England in ten years' time our younger men would show them that we, too, could make progress and take advantage of the great opportunities which had been given to us in Germany of instructing us in the way of applying this new power. Using the privilege of age, he would give them a little of his own family experience. Some fifty years ago his father was a manufacturer of locomotive engines who went to Germany for orders, and he had the opportunity of supplying locomotive engines to Germany, which no doubt they made most valuable use of; but, alas! those days were no more; Germany was now supplying our own Colonies with German locomotives. But our progress had been equally

* The following is the text of the telegram:—

"Ew. Majestät, dem zuverlässigen Schutzherrn des Friedens, senden ehrerbietigen Huldigungsgruss 600 Mitglieder des Iron and Steel Institute, die in Vereinigung mit zahlreichen deutschen Fachgenossen soeben ihre höchst befriedigend verlaufene Versammlung in Düsseldorf abhielten und die bewunderswerthe Ausstellung dieser Stadt besichtigten."

To this message the following gracious reply was received:—

"Seine Majestät, der Kaiser und König, haben den Huldigungsgruss der dort versammelten Mitglieder des Iron and Steel Institute gern entgegengenommen und lassen bestens danken."

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doubtedly a great source of strength to their international Institut that the roll of members contained so many German names. Thei transactions had been enriched by most important papers contributed by such men as Daelen, Brügmann, Schrödter, Massenez, Heyn, Kylberg, and Eyermann. The Institute's list of Bessemer medallists was adorned by such names as Friedrich Alfred Krupp and Hermann Wedding. The thus saw that the Institute's debt to Germany was a great one, and had been still further increased by the great kindness and hospitali that was now being accorded to them on the occasion of that gatheri in their delightful city of Düsseldorf. He concluded by again thanki Commerzienrath Brauns for his too flattering remarks.

Mr. BEUMER proposed the toast of "The Ladies" in a humorou speech, to which Professor H. M. HOWE replied.

Professor WEDDING, in proposing the health of Sir Lowthian Bel said it was now nearly thirty years ago since the members of the Iro and Steel Institute elected a President, who was now among them That President, in his presidential address, said the important thing f the Institute to bear in mind was to unite practice and science, and S Lowthian was certainly right to say that, because he got his educatio in Germany, which was a country of scientists, and after that he de with the iron ores in England, and that was the country of practic It was not every man who filled properly the position to which had been called, but Sir Lowthian certainly did so, and not only th members of the Institute in England and Germany were thankful him for what he had done, but the whole world was indebted to hi He gave them the toast: "The Nestor of the Iron Industry, Sir Lo thian Bell, with three hearty cheers."

Sir LOWTHIAN BELL, Bart., on rising was received with loud and p longed cheers. He said he was not going at that late hour of the even to detain them very long, but before he sat down he thought he would able to convince them that instead of having rendered any great serv to the science of iron and steel, his own feeling was that he ought have done a great deal more than he had done. It was his good fortu nearly seventy years ago to visit the town of Berlin, and he took wi him a letter of introduction to their great and immortal Alexander v Humboldt. That letter brought for him a very friendly reception fr the great men of that day, from Von Dechen, Michelet, Karsten, a many others. Since that time a friendship had been acquired by hi self with men like Ritter von Tunner and others, and therefore he f instead of meriting all that Professor Wedding had said for him—

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remember that it was from England that they had originally obtained instruction in practical working, Mr. Longsdon having been the link between the firm and the country from which the visitors came. Mr. Whitwell made a happy reply, in which, on behalf of the Institute, he expressed the appreciation of the fact that Mr. Krupp had departed in their favour from his usual rule of closing the works to strangers. At about 4.30 P.M. the party, having seen as much of the works as time permitted, were taken in a special train to the Villa Hügel, the residence of His Excellency F. A. Krupp, where they were received by Mr. and Mrs. Krupp and the Misses Krupp. Here the visitors were magnificently entertained, after which they inspected Mr. Krupp's studio and picture gallery, which are treasure-houses of art. It was observed that the Bessemer medal of the Institute, which has recently been awarded to the host, was lying on a table in the library. In the evening the party, thoroughly gratified by their reception, returned to Düsseldorf.

The 130 members who selected the Dortmund excursion left Düsseldorf by special train at 7.51 A.M., arriving at Dortmund at 9.26 A.M. The party then visited the Hoerde Works. After inspecting these works the company split up into two sections, one of which was taken to the Hoesch Iron and Steelworks, and the other to the Union Iron and Steelworks at Dortmund. When the round of the works had been completed the members met at the Hotel zum Römischen Kaiser, when luncheon was offered to them by the three companies. Regierungsrath Mathies, who presided, made an admirable speech welcoming the guests; and Mr. Arthur Cooper, Member of Council, expressed the thanks of the members for their hospitable reception.

The members, about sixty in number, who elected to take part in the Ruhrort excursion were met at the Duisburg railway station by Mr. von Kraewel, and proceeded in special tram cars, kindly provided by the companies, to the works, one half going to the Phœnix Works, and the other to the Rheinische Stahlwerke. On leaving the Rheinische Stahlwerke the party had a pleasant surprise. On the quay-side they were met by Mr. Prüsmann, the Chairman of the Royal Harbour Commissioners, and proceeded in two special steamers gay with bunting for a trip round the harbour amid cannon salutes and dipping of flags of the vessels passed. At the harbours at the mouth of the Ruhr (a portion of the Rhine only eight miles long) 14,300,000 tons were handled in 1901. Adding the goods in transit, there is obtained a total water traffic of more than 18,000,000 tons, a figure not attained at any other point in the world in inland navigation.

furnaces at Hochfeld-on-the-Rhine, while the other group were conveyed in carriages to the Duisburger Machine Company's works (formerly Bechem & Keetman's) at Duisburg. At the latter establishment they were received by Mr. Wilhelm Keetman, Commerzienrath Julius Weber, and a number of the officials, by whom they were conducted over the works, which give employment to about a thousand hands. The great feature of the Company's works, which have an annual output of 300,000 tons of castings, is the extensive use of electric power for driving the machines, &c., in all the workshops. The visitors were there pleased with all that they were shown. The inspection lasted between two and three hours. At the close of the visit the party was driven to a landing-stage on the Rhine, where the steamer *Prinz Heinrich*, gaily decorated with flowers, plants, and bunting, was awaiting them. A salvo of guns having been fired in their honour, the steamer proceeded down the river for some miles, and after about an hour returned to Duisburg and Düsseldorf. A magnificent luncheon was served on board. The following works had united in entertaining the members: Vulcan, Johannishütte, Kupferhütte, Niederrheinische Hütte, Duisburger Eisen- und Stahlwerke, Röchling Brothers, C. Heckmann, Hochfelder Walzwerke, Kiefer Brothers, Harkort Company, and Bechem & Keetman.

Towards the end of the luncheon Commerzienrath Julius Weber said they were told that commerce and industry had a tendency to bring men together. That was especially the case in times of depression, when difficulties were experienced in finding a home market and when manufacturers were forced to look around them in order to develop an export trade. It might, indeed, be said that the Exhibition at Düsseldorf had brought England and Germany together. At that Exhibition the Rhenish provinces showed the best of their products, and he hoped that, as a result, more trade would come to them. A custom had sprung up in connection with industrial exhibitions of discussing not only the best means of pushing trade, but of producing the best and cheapest goods. In that neighbourly sentiment they were united with the members of the Iron and Steel Institute, who were their guests that day. It was the duty of the German manufacturers when they found that trade was bad to show the world what they could do and what they had to offer. They felt grateful to the members of the Institute for coming to see the Exhibition at Düsseldorf, which showed what had been accomplished in that district after forty years of hard work. Englishmen, he had no doubt, would appreciate all that had been shown them. It could not be otherwise but that competition would

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tunity of travelling on the hanging railway.* The railway, which is operated by electricity, connects Vohwinkel, Elberfeld, and Barmen. It is to be about eight and a quarter miles in length, and only about three-quarters of a mile have to be completed. The whole of the structural part and the stations will be finished by February 1 next, and the line will be opened for traffic up to the terminus, Barmen-Ritterhausen, by about March. The return journey to Düsseldorf was resumed at about 6 P.M. The whole of the visitors were struck with admiration at the daring scheme of the electric suspended railway, which works with astonishing smoothness at a speed of about 18 miles an hour. The excursion was organised by Mr. R. M. Daelen.

Ladies' Excursion.

A special programme of visits and excursions was drawn up for the ladies attending the meeting. On Wednesday, September 3, the ladies assembled at the Rhein-Tor of the Exhibition at 10 A.M. and visited the Palace of Fine Arts and other portions of the Exhibition under the guidance of the Ladies' Reception Committee. On September 4, the Municipal Art Gallery and the Museum of Industrial Art were visited. On September 5 the Exhibition and objects of interest in the town were visited. The Ladies' Committee consisted of Mrs. Beumer, Mrs. Daelen, Mrs. Hahn, Mrs. Korten, Mrs. E. F. Lange, Mrs. H. Lueg, Mrs. G. H. Müller, Mrs. Sack, Mrs. Schrödter, Miss Spannagel, Mrs. Alexander Thielen, and Mr. Richard Pink.

NOTES ON WORKS VISITED.

The Union Mining Company and Iron and Steel-works, Dortmund.

These works were established in 1872, being formed by the amalgamation of the following works: (1.) The Heinrichshütte at Hattingen, comprising a foundry, blast-furnaces, puddling works, rolling mills, and workshops. Further, the Carl Friedrich mine at Weitma, and ironstone mines. (2.) The Neuschottland Company at Horst, comprising blast-furnaces, puddling works, rolling mills, and foundry. Also iron-

* The Elberfeld hanging railway is described in detail in the *Engineer*, vol. xciv. pp. 385-386, 413-415, 435-436.

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engines, and 92 machine tools. Here are made locomotive and railway carriage wheels for heavy and light railways. The annual output is about 10,000 tons. Besides these there is a fitting-shop and foundry, with 3 cupolas, 5 reheating and reverberatory furnaces, 5 steam engines, and 52 machine tools for the manufacture of chill moulds, rollers, and other castings, also for the repair work necessary for the works them selves. The railway carriage works is a recent addition to the plant, being fitted with the most up-to-date appliances of every kind. Trucks and cars of every description for goods traffic are built, also railway passenger carriages. One thousand railway vehicles are turned out annually. At the Dortmund Harbour there has recently been erected a ship-building yard with the newest machinery and appliances for building small vessels of every kind, such as barges, pontoons, and lighters up to 210 feet in length and 27 feet 6 inches in width. Repairs of every description are carried out on the wharf, special hoisting apparatus being provided for lifting vessels not exceeding the above dimensions.

The Hoesch Iron and Steelworks, Limited, Dortmund.

The Hoesch Iron and Steelworks were founded in the year 1871 by the members of the Hoesch family of Düren. The first manager of the works was the late Albert Hoesch, who died in 1898. Under his management the firm developed from small beginnings to the extent at the present day. In the first years the firm was engaged solely in the manufacture of Bessemer steel for rails and other railway accessories, and the installation consisted of 3 converters, each of 6 tons capacity, 1 forge, and a rolling mill. The number of men employed was 300.

At the present day the works comprise the following departments:—

1. A coke-oven plant of 190 ovens, 60 of which are Coppée ovens, 30 Brunck ovens, and 100 Otto-Hoffmann ovens. 130 of these have by-product plants attached for the recovery of tar and sulphate of ammonia. The yearly production is about 210,000 tons of coke, 4700 tons of tar, and 2100 tons of sulphate of ammonia.

2. A blast-furnace installation of 4 furnaces with 17 Cowper hot-blast stoves, 42 steam boilers and an electric central power plant with 4 dynamos of an aggregate power of 1100 kilowatts. The current is generated by 2 gas-driven engines each of 300 horse-power, and each coupled direct to 1 dynamo of 225 kilowatts. Further, there are 6 blowing engines each of 6000 horse-power and a slag cement factory.

The works comprise three main divisions, viz. :—

1. The blast-furnace installations at Hoerde and Dortmund.
2. The Hermann Ironworks at Hoerde, and
3. The Hoerde Colliery, with the Schleswig pit near Brackel, and the Holstein pit near Asseln.

Blast-Furnaces.—The Hoerde blast-furnace installation consists of 6 large blast-furnaces, and is fitted with every modern appliance to enable 5 furnaces, with an annual output of 330,000 tons of pig iron, to be worked continuously. Various kinds of pig iron, chiefly basic, are smelted.

The pig iron mixer here was the first one ever built in Europe. It consists of a tilting vessel always filled with well-mixed liquid pig iron, tapped from different blast-furnaces. It was first put into operation in 1890.

The Dortmund plant is not in operation at the present time. It consists of two blast-furnaces capable of producing 100,000 tons annually.

The central electric power station erected within the Hoerde Works consists of five blast-furnace gas-driven engines, three of which are of 600 horse-power and two of 100 horse-power. These drive dynamos which generate a polyphase current of 3000 volts pressure. The electric energy obtained is utilised at the Hermann foundry and in the coal mines.

The Hermann Foundry is divided into several sections. The basic steelworks, with four converters, has a monthly output of 30,000 tons of steel ingots. The open-hearth steelworks with nine furnaces produces about 10,000 ton of open-hearth steel ingots per month. The blooming mill, with a monthly output of 28,000 tons, can roll the heaviest ingots, at one heat, to blooms and finished material, such as flats, billets, heavy girders, state railway rails, and tramway rails. In the steel rolling mill, tramway rails, sleepers, medium-sized girders, and flat bars, also ships' angles and bulb iron, are rolled. The output is from 5000 to 7000 tons per month. In the rod rolling mill about 3000 tons of material per month are rolled in the roughing and intermediate trains, and about 1600 tons per month in the finishing rolls—rods, mine rails, angles, light girders, and merchant iron being the chief products. The universal rolling mill turns out 1000 tons of bar or merchant iron of all sections. The plate mill produces monthly about 5000 tons of rough plates, such as ship plates, tank plates, boiler plates of open-hearth mild steel, locomotive engine frames, and corrugated sheet iron; also 1000 tons per

For the traffic within the works 44 engines are employed. They also own 380 standard-gauge railway cars.

The total number of employés is about 500. An invalid fund and an old-age pension fund are organised for the workmen, and another pension fund exists for the clerks and officials.

The company owns besides: a hospital for invalid and injured workmen, barracks for workmen without families, 220 dwelling-houses for employés and working men containing 762 separate suites of rooms, and a club for the employés (clerks, officials, &c.).

The Vulcan Blast-Furnace Works at Hochfeld-on-the-Rhine.

The Schalker Gruben und Hütten-Verein owns three blast-furnaces, of which two are at present in operation. One of these is 20 metres (67 feet) in height, the other 18 metres (60 feet) high, and both are working at the present time on hæmatite pig. The whole of the blast-furnaces are fitted with Cowper stoves. The company manufactures its own coke in Coppée ovens without recovery of by-products. The slag is conveyed direct from the blast-furnaces by a wire rope-way to the dumping ground. A noticeable feature about one of the blast-furnaces is the thick iron plating of which the body of the furnace and the bosh are formed, which is lined with fire-brick of the thickness of 70 mm. only (under 2½ inches). The whole exterior furnace is cooled by means of water. The design and type of construction is patented in all iron-producing countries.

This furnace is the outcome of the experience that the life of blast-furnaces when hard driven is only a short one, since the refractory masonry, especially that of the body, soon loses its form, thereby causing irregularity of working, besides an increased consumption of coke. The new furnace at the Vulcan Works has now been three years in successful operation, even when working for long periods upon the production of ferro-manganese and ferro-silicon. It is now therefore definitely assured that the furnace will not require to be put out of work on account of internal deformation. It should also be mentioned that in this furnace both the bosh, crucible, and hearth are lined with carbon bricks. Two other blast-furnaces of the same type are in course of construction, one of which will have a daily output of 500 tons, and the other of 250 tons. The Siegen collective exhibit in the Düsseldorf Exhibition contains a

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at Meppen, the Krupp steelworks, formerly F. Asthöwever & Co., at Annen in Westphalia, the Germania wharf at Kiel, 4 blast-furnace plants at Duisburg, Neuwied, Engers, and Rheinhausen (the last named consisting of 3 blast-furnaces, with an out-turn of 180 to 230 tons per furnace per 24 hours), works at Sayn with engineering works and iron foundry, 3 collieries, a large number of iron-ore mines in Germany, a share in iron-ore mines in Bilbao, and docks in Rotterdam with steamships. The chief products of the Essen Works are guns (up to January 1, 1902, there have been sold 39,876), mortars, gun-barrels, armour plates for warships and for fortifications, railway material, shipbuilding material, machine parts of all kinds, steel and iron plates, rolls, tool steel, hard steel, special steels, steel winches, &c. At the cast-steel works in 1901 there were in the sixty departments in operation 5300 machine tools, 22 rolling mills, 141 steam hammers of 2 cwts. to 50 tons falling weight, the aggregate being 242¾ tons falling weight; 64 hydraulic presses (including two bending presses of 7000 tons, a forging press of 5000 tons, and one of 2000 tons), 323 vertical steam boilers, 513 steam engines, of 2 to 3500 horse-power, aggregating 43,848 horse-power, 369 electro-motors, 591 cranes of 8 cwts. to 150 tons capacity, aggregating 6328 tons capacity. In the smelting works in 1901 there were smelted on an average 1914 tons of iron ore from the firm's mines daily. The coal output from the firm's collieries in 1901 was 1,479,334 tons. The total consumption of the Krupp Works in 1900–01 was 995,298 tons of coal (of which the cast-steel works alone used 765,589 tons), 473,044 tons of coke, and 97,195 tons of briquettes. Converted into equivalents of coal, this represents an aggregate consumption of the Krupp Works, in so far as it is provided from Essen, of 1,678,175 tons. At the Meppen gun testing grounds 735 ballistic tests were carried out in 1901. The total number of family dwelling-houses in the workmen's colony of the firm on January 1, 1902, was 5469. The total number of persons employed at the Krupp Works, including 3959 officials, on April 1, 1902, was 43,083. Of these 24,536 were employed at the Essen cast-steel works, 2773 at the Gruson Works in Buckau, 3987 at the Germania ship-yard in Kiel, 6159 at the collieries, and 5628 at the smelting works, Meppen grounds, &c. The number of persons dependent on the Krupp Works in May 1900 (including women and children) was 147,645. His Excellency F. A. Krupp, who so hospitably entertained the Institute on September 5, died suddenly on November 22. An obituary notice is given elsewhere in this volume.

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furnaces, four annealing furnaces, three open-hearth and four crucible furnaces. Also 20 steam engines and seven large steam hammers, and 300 machine tools. The departments consist of an erecting shop, an iron and brass foundry, a steel-casting foundry, a forge, a press forge, and a bridge-building works.

2. *The Oberhausen Rolling Mills.*—These contain 16 puddling furnaces, 13 re-heating furnaces, and two rotary furnaces. Also 11 trains of rolls, 58 steam engines, and seven steam hammers.

3. *The Oberhausen Ironworks*, with nine blast-furnaces.

4. *The New Oberhausen Rolling Mills.* — These consist of a basic Bessemer and open-hearth steelworks with four converters and four open-hearth furnaces, seven re-heating furnaces, 10 trains of rolls, and 102 steam engines with six steam hammers. The firm also possesses its own coal mines and 150 coke ovens, 90 of which are combined with by-product recovery plants. They also own numerous iron-ore mines in Nassau, in the Siegerland and in Lorraine, besides a factory for refractory material, dolomite and limestone quarries, three brick-making factories, one waterworks, 72 dwellings for the works officials, 211 workmen's dwellings, and four barracks for the unmarried workmen with accommodation for 1032 men. In 1900 the production of pig iron at these works was 397,953 tons, and the output of the rolling mills was 310,375 tons of iron and steel products. Besides these, engines, boilers, bridges, and cast-iron goods to the amount of 46,615 tons were manufactured. In the same year 1,372,447 tons of coal were raised, and 305,990 tons of iron ore, 108,810 tons of limestone and 13,940 tons of dolomite were consumed. The number of workmen and officials employed is 13,640, the wages and salaries paid amounting to £923,300.

The Rheinische Stahlwerke Company, Meiderich, Ruhrort.

This company was formed in 1870. It has a capital of £1,350,000. The operations of the company comprise the three sections: (1) the Meiderich Works, (2) the Centrum Colliery at Wattenscheid, and (3) the iron-ore mine at Algringen. The main operations at the Meiderich Works consist in the preparation of rolled products of all kinds with the heat of the iron from the blast-furnace, without further consumption of coal or coke for the whole process of the steelworks and rolling-mill practice. The entire production of the basic steelworks, and a portion of the outturn of the open-

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(5) the coal mines; (6) iron mines and deposits in the Rhine Province in Hesse-Nassau and Lorraine—these latter are owned conjointly with the Gutehoffnungshütte; (7) the works of the Westfälische Union at Hamm, Lippstadt, Belecke, and Nachrodt. The total number of workmen employed at present amounts to about 12,000.

The works thrown open to be visited at Laar comprises blast-furnaces, rolling mills for blooms, slabs, rails of all kinds, bar-iron, wire, &c.; and also, a basic Bessemer and open-hearth steel plant, a tire rolling mill, a fitting shop, and an iron foundry. These employ about 4500 workmen. The blast-furnace plant consists of six blast-furnaces, three of which are of 200 cubic metres capacity, and three new furnaces which have a capacity of 480 cubic metres. Four of these are in operation, and are principally working on basic pig iron to supply the requirements of the steelworks. Ferro-manganese is also produced. The plant is equipped with 19 Cowper hot-blast stoves, six blowing engines of about 4500 horse-power, 42 steam boilers with an aggregate heating surface of 4200 square metres, and a pressure of 120 lbs. per square inch. There are besides two Solvay coke-oven batteries, each of 24 ovens with by-product recovery plants, two Otto batteries, each of 32 ovens, and one Otto battery of 60 ovens. The entire production of the coke ovens in 1901 was 131,400 tons. The blast-furnaces produced during the intermittent working period of 1901, 151,910 tons. For the production of this latter there were consumed 333,000 tons of iron ores, 53,000 tons of limestone, and 16,900 tons of coke.

The basic steelworks consists of three converters, only one of which is continuously worked, the others being kept in reserve. The weight of the charge of liquid pig iron is 12·5 tons, and the blowing period is nine to fifteen minutes. The pig iron is brought partly direct from the blast-furnaces, the rest of the charge being remelted in the cupolas before charging. The liquid iron from the blast-furnaces and cupolas is poured into a mixer of 150 tons capacity, which serves to equalise the working of the steelworks and the blast-furnaces. At the same time the mixer is employed for rendering uniform the quality of the pig iron, and for desulphurisation. The liquid iron is poured off from here into the converters. The resulting mild steel always contains about 0·05 per cent. of carbon, and is thus of the very softest quality. When a harder material is required the patent carburisation process of the Phœnix Company is employed, by which steel of 0·2 to 1 per cent. of carbon is produced. The steel is cast in single ingots, each

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The Elberfeld Suspended Railway.

The electric suspended railway connecting Vohwinkel, Elberfeld, and Barmen is not only an object of interest to the general public, but also to the technical world; and eminent engineers from all parts of the world have travelled to Elberfeld with the object of seeing it. The scheme is now approaching completion, and in the portions already at work improvements have been carried out where such appeared desirable.

The entire distance from Vohwinkel to Barmen-Ritterhausen is 13,300 metres (a few yards over 8¼ miles). The first portion, nearly 3 miles in length, from Elberfeld-Kluse to the Zoological Gardens, was opened in March 1901. Some months later another section of 3 kilometres (about 1¾ miles) was opened as far as Sonnborn-Vohwinkel, and of the remaining 3½ miles there is now only little over three-quarters of a mile to complete. The whole of the structural part and the stations will be finished by the 1st of February 1903, and the whole line will be opened for traffic up to the terminus, Barmen-Ritterhausen, perhaps by March 1. Some annoyance was caused at the commencement of working by the noise of the cars, but this trouble has now been remedied. Unpleasantness was also at first caused by the slow sideways rocking motion which in the case of many passengers produced a sensation similar to that experienced in a ship at sea, but this difficulty too has been entirely got over in the case of trains composed of more than one car. It is hoped soon to overcome the tendency of a single car to sway. As soon as the whole section is open the company will seek permission from the railway administrative authorities to raise the speed from 18 to 30 miles per hour. That this increase in the speed will not interfere with the smooth running of the carriages has been certified to by three eminent engineers, Dr. C. Köpke of Dresden, Professor A. Goerin of Berlin, and Von Borries, consulting engineer for State railways at Hanover. These gentlemen state in their report that on April 18, 1902, in their presence, the speed, which ordinarily was 30 to 37 kilometres (18 to 22 miles), was increased to 40 to 50 kilometres (24 to 30 miles). This was maintained on curves of 90 metres radius (295 feet) and was continued through several stations without stopping. Whether on the straight line or on the curve no difference was perceptible in the motion of the car. A glass of water set on the floor, filled to within half an inch of the brim, did not spill one drop of the liquid throughout the whole journey there and back.

of a combined horse-power of 190 horse-power, which drive three dynamos. The current is distributed to the various motors which actuate the different machines. Two Dürr boilers supply the steam to these engines, the total heating surface being 203 square metres. The principal building, the boiler shop, is 330 feet long, 80 feet wide, and 43 feet high, and the central portion is served by two travelling cranes, each of 15 tons. The two side wings contain four smiths' hearths, with five travelling cranes, each of 5 tons capacity. The erecting and fitting shop is a lofty building of 14,000 square metres area. The boilers are hoisted on board the ships by means of a large slewing crane of 25 tons capacity and 33 feet radius.

Ernst Schiess, Machine Tool Works, Düsseldorf-Oberbilk.

The works were founded by the present owner, Mr. Ernst Schiess, on the 1st January 1866, under very adverse circumstances. The works employed about 20 hands in 1866, while at the present time the number of officials and workmen is about 1000. The plant consists of 8 steam boilers, with a total heating surface of 1000 square metres, 3 steam engines, with a combined horse-power of 850 horse-power, forming a central station for the generation of power and light. There are besides 65 electric motors, and other modern appliances. The iron foundry is capable of dealing with castings up to 50 tons in weight. The fitting shops contain about 400 machine tools, among which are 160 lathes, 32 planing machines, &c. The driving of the whole machinery is effected by electrical power supplied by the central station. The firm manufactures machine tools for ironworks, for wheel and axle manufactories, for roll manufactories, for boiler-making works, for tube-rolling works, shipyards, engineering works, electric engineering works, gas-engine, locomotive and waggon works. Repair work for railways, and work for manufacturers of artillery, projectiles, and small arms of all descriptions, are also carried out.

Haniel & Lueg, Düsseldorf-Grafenberg.

The works, which were established in 1873, are situated in Grafenberg; they employ about 2000 workmen, and comprise the following departments, viz.: Engineering works, iron foundry, cast-iron tube works, open-hearth steelworks, forge and hammer works, hydraulic forging and pressing plant.

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This firm are regular contractors to the Imperial Navy and the State Railways, as well as to the leading locomotive engine builders, electric works, shipbuilding yards, engineering works, rolling mills and forges, bridge-building works, &c., both at home and abroad. Their manufactures are celebrated on account of their neatness of finish, soundness and ready workability.

The works also supply wheels and sets of wheels for light railways, tramways, and field and mine railways, in large quantities, from their own designs; spikes for mine rails being a speciality.

All appliances are maintained in a fully up-to-date condition. The open-hearth furnace plant comprises three furnaces of from 10 to 12 tons capacity.

The Sack Engineering Works, Limited, Rath, near Düsseldorf.

The Sack Engineering Company is engaged in the manufacture of rolling mills and all auxiliary machines for steelworks, such as shears and presses of all kinds, machines for dressing angles and plates, bending machines, roll-turning lathes, hydraulic apparatus of all kinds, especially steam hydraulic apparatus, also machine tools for shipyards. The works are well adapted for dealing with portions of machinery up to 60 tons in weight. They are of quite modern construction, and are equipped with machine tools so designed that one piece of work can be machined at the same time with several tools.

The De Fries Company, Limited, Düsseldorf.

The speciality of these works consists of machine tools of the most modern type, particularly vertical drilling machines, lathes, planing machines, punching machines, shaping machines, forges, steam hammers, &c., &c. All the workshops are supplied with electric power and light from the power station. Some of the machine tools in use weigh 60 tons, and are capable of taking the heaviest pieces of machinery. In the machine department there are altogether 148 machines in operation, mostly driven by electric motors in groups. Some of the larger machines, however, are driven by electric power independently. The iron foundry is equipped with the most modern appliances, and castings up to 30 tons in weight can be turned out. The forge is supplied with smoke preventive means, the smoke being drawn off by suction directly above the fires.

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that necessary for lighting and for supplying the extensive testing sheds, where all motors before sending out undergo a severe trial, is supplied by an illuminating gasworks capable of generating 1,000,000 cubic metres in the year, and by two gas-producer installations, which yield 4000 cubic metres per hour. The number of machine tools comprises 300 lathes, 100 planing and milling machines, 70 drilling machines and other special tools. For the manipulation of the heavy parts of the machinery 10 electrically-driven travelling cranes are provided, with lifting capacities up to 30 tons.

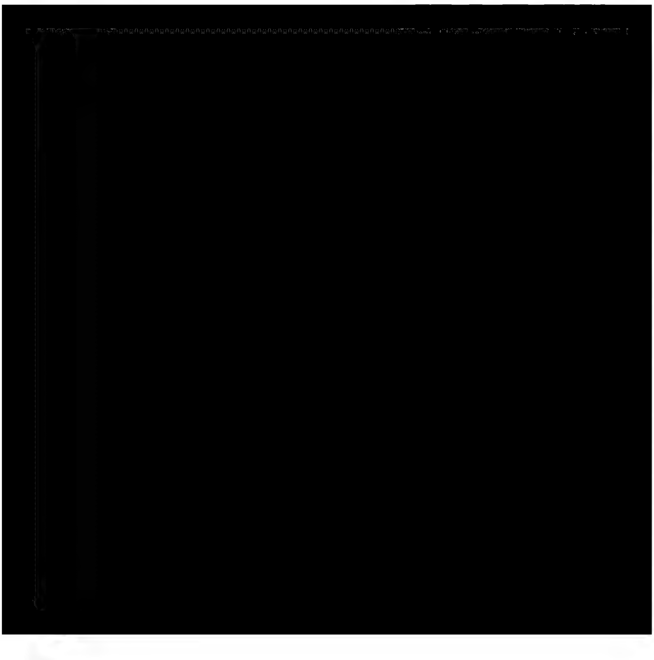
The Humboldt Engineering Works, Kalk, near Cologne.

These works have been in existence since 1856, the area occupied by them being 97,857 square metres. The works comprise: A foundry, the main production of which consists of castings of all sorts and sizes—in particular, steam cylinders, also retorts for chemical works, and other pieces, cast in open sand moulds. A speciality of the works is chilled castings, for all kinds of dividing or disintegrating machines. A forge, boiler works, and erecting shop. Here are made Cornwall boilers, water-tube boilers, water-purifying apparatus, plate or sheet metal weldings, apparatus for the chemical and sugar industries, and iron structures of every description, including bridges, &c.

Engineering Works.—The chief articles of manufacture are: dressing machinery for ores, coal, and other minerals; mining machinery, machines for foundries and other industrial purposes; steam engines, steam turbines, steam-pressure hoists or elevators, ice machines, and air-cooling plant; plant for chemical works and potteries, complete plant and fittings for briquette making, from coal and lignite; also machinery for india-rubber, linoleum, and wire-rope manufactories, &c. Among the above specialities, the coal and ore dressing apparatus are the best known; plant of this description, supplied by the Humboldt Works, having been erected in all parts of the world. In fact, there is attached to the works a testing laboratory for coal and ore dressing and crushing machinery.

Perforating Works.—The oldest in Germany. Supplies perforated metal sheets and plates of every description; also corrugated plates.

Locomotive Works.—This newly-fitted department, comprising a forge, machining shop, engine-frame building shop, fitting shop, and varnishing shop, has been kept fully employed with both Government contracts and private orders ever since it has been in operation. About 200



complete harbour equipments, locomotive cranes, coal shipping appliances, ore conveyers, electric locomotives, special appliances for glass works, casting cranes, &c.

(2) Iron and Steel Works Section. Here are manufactured complete machinery installations for mines and ironworks, driven either by gas, electricity, hydraulic power, or steam. Besides these are supplied blast-furnace installations, steel and rolling-mill plant, ironwork for open-hearth and re-heating furnaces, converters, electrically driven rolling mills for tires and discs, winding engines, charging machines, cooling beds, &c.

THE AACHENER HÜTTEN-ACTIEN-VEREIN, ROTHE ERDE, NEAR AIX-LA-CHAPELLE.

The iron and steelworks of the above company were laid out in 1845, and from extremely modest beginnings the works have been gradually extended, particularly during the last ten years, until they have obtained their present dimensions. In 1892 the blast-furnace works at Esch in Luxemburg was purchased, and also iron-ore mines and concessions were obtained in Luxemburg and Lorraine, where ore has been mined in recent years. The works at Rothe Erde consist of:—

1. A basic Bessemer steelworks of 30,000 tons yearly capacity, comprising three converters, five cupolas, two twin-blowing engines, each of 2500 horse-power, four two-throw steam pumps to supply the hydraulic accumulators, six fans driven by a steam engine, 16 hydraulic cranes, three hydraulic tipping gears for converters and appliances for lifting the bottoms. Also a hydraulic casting crane, two locomotive steam-driven casting cranes, two testing hammers, and a central condensing plant. This latter consists of a steam engine with air pump, and two rotary pumps for supplying the water, with an hourly delivery of 7800 cubic metres each.

2. An open-hearth steelworks with three furnaces of 25 tons capacity, eight gas producers, one electric charging machine, two electric travelling cranes of 50 tons each, two similar ones of 15 tons and five tons capacity respectively, two fans, electrically driven, and an electrically driven pneumatic hammer. The yearly outturn of the open-hearth steelworks is 70,000 tons.

3. A rolling mill with 13 trains of rolls, two of which are large blooming mills upon which rails, sleepers, fishplates, and all kinds of railway material are rolled. Also girders up to 1 foot 10 inches in

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for driving the above plant is generated in 71 steam boilers, with a total heating surface of 5900 square metres. The company control a section of standard gauge railway 13 kilometres in length, and 11 kilometres of narrow gauge railway. They own besides five large and 11 small locomotives, also a number of trucks and two locomotive cranes. For the loading of the finished material six electric travelling cranes and one electric locomotive crane are provided.

The Excursion to Peine and Ilsede.

Although distant about 200 miles by rail from Düsseldorf, and in spite of various counter attractions at and about that fascinating city, some twenty members joined the excursion to visit the interesting works at Peine and Ilsede.*

The proprietors of these works commenced operations in 1860, the title of the proprietary company being "Die Bergbau und Hütten-Gesellschaft Ilseder Hütte zur Gross-Ilsede bei Peine" (The Mining and Smelting Company of the Ilsede Smelting Works at Gross-Ilsede near Peine). The ironworks at Ilsede were started to utilise the large deposits of brown iron ore at Adenstedt and Gross-Bülten, and the blast-furnaces were connected with the mines by a narrow-gauge railway, and with the Hanover-Brunswick line at Peine by a normal-gauge line. Then in 1872 an independent company erected the Peine puddling and rolling mill to work up to better advantage the Ilsede pig iron, which had hitherto been exported. But in 1879, when the Thomas-Gilchrist process was introduced, the Ilsede company, realising the immense significance of this process and quickly resolving to make use of it, purchased the Peine works and then gave them the character they have since retained, of a basic Bessemer works in conjunction with a steel mill.

On the present occasion Düsseldorf was left in the evening, and somewhat after midnight the visitors were installed for the rest of the night in Hanover. Early the next morning a start was made, and Peine, twenty-two miles away, was reached at 9 A.M. The company was represented at the station by various gentlemen, including Messrs. Dreger, Reiss, Steckhaer, Gerhard Meyer, and Dr. Geldmacher, and after a few moments spent in introductions, the party was speedily on the way to the Peine works and mills.

These works are arranged in three departments: the puddling and

* Mr. D. A. Louis has kindly prepared this report.

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Following a principle rather of *proxime accessit* than of any systematic inspection, steel mill No. 3 was next entered. It covered an extensive area and accommodated another three trains of rolls—namely, one finishing train with rolls of 2 feet 10 inches diameter, and with lifting tables and live rollers driven electrically; another train with rolls of 2 feet $10\frac{1}{2}$ inches diameter, on which are rolled round and square iron; and a third train consisting of rolls 2 feet 7 inches in diameter, upon which section bars are rolled. The whole of the current is supplied from Ilsede. Twenty-inch girders 80 feet long were being rolled at the first of these direct from the ingot without blooming, the time occupied being 6 minutes to the hot saw. The reheating-furnaces were on the Bildt system, and charging was done with hydraulic ram or with a swinging arm worked hydraulically. Beyond this mill was the yard, impressive on account of its vast area, its well-stocked condition, and the two busy transporters—one American and one German—employed in loading up railway waggons. The Peine mills only roll for stock and to standard patterns, 35,000 tons of stuff being stocked.

Having passed up and down the yard, the party next visited mill No. 2, which was busy on small sections, running them through in two minutes with 17 passes. It contained three trains of rolls—one roughing train, with rolls of $21\frac{1}{2}$ inches diameter, for small sections, heavy bar iron, and mine rails; one medium train, with rolls of $17\frac{1}{2}$ inches diameter, for thin bar iron and mine rails; and one quick set of roughing rolls, with rolls $10\frac{1}{2}$ inches in diameter, for bar and hoop iron.

Near mill 2 was the open-hearth works, where one furnace was in course of construction, but of three 25-ton furnaces already erected two were working; they work entirely on scrap and were being run in five-hour heats. The daily output of each furnace is 110 tons. The furnaces are lined with dolomite, are fired with water-gas, and the regenerators have a capacity of 60 cubic metres. The reversing is effected by means of Forter valves. There are nine gas producers with steam and air blast, and one water-gas producer on the Dellwik-Fleischer system, with automatic fuel-feeding apparatus.

The charging platform of the furnace is on a level with the floor of the casting house, and there is one electric charging machine, with a capacity of $1\frac{1}{4}$ tons, which travels upon a ground track. This is worked by four continuous-current motors, and was made by Lauchhammer. The easy and precise working of this machine was successfully demonstrated.

The casting house is served by a 40-ton electric travelling crane, of American design, and two 5-ton cranes for handling ingots and moulds.

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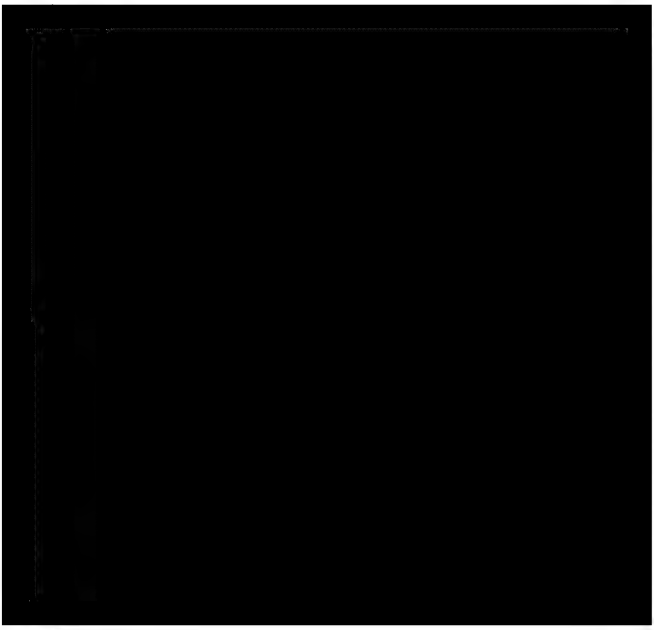

The Ilsede Works.

A quarter of an hour's ride over the company's private line brought the visitors to Ilsede, and steps were directed to an attractive building in the vicinity of the station. In one of the rooms of this nicely decorated building an excellent luncheon was served, but loitering was wisely discouraged. Refreshed by one or two delicacies, washed down with any of a large selection of beverages, the visitors were soon again at work looking at the blast-furnaces and the accessories.

These works are situated near the great ore deposits already alluded to above, whilst the ores are obtained from two of these deposits, and also from a mine situated in the Harz region. The ores of the two former mines are basic in character, while those from the latter are acid; the mixture of ores is self-fluxing, and produces a pig containing over 2½ per cent. of phosphorus. The slag is used for road-making. Tap cinder is also used in small quantities as an addition to the charge. The reduction of the ore is carried on in four blast-furnaces, three of which are in continual operation, and one in course of construction. The furnaces are 65 feet in height and have a capacity of 14,128 cubic feet; they are fitted with seven tuyeres of 7 inches diameter at the nozzle. The production of pig iron per furnace per day amounts to 215 to 220 tons, with a maximum output of 250 tons. The total production of the three furnaces during last year was 226,000 tons. One-third of the coke used in smelting is produced at the works, and the remaining two-thirds is obtained from Westphalia. The quantity of air for the blast amounts to 77,700 cubic feet per minute at a pressure of about 9 lbs. per square inch. This air is supplied by six blowing engines, both of old and modern construction, one of which is driven by blast-furnace gas. This latter supplies 14,128 cubic feet of air, while developing 500 horse-power. The motor is two-throw and was supplied by Oechelhäuser. The blast cylinder is 5 feet 2½ inches in diameter, 3 feet 1 inch stroke, and 66 cubic feet capacity. The gas-engine cylinder s 26½ inches in diameter and 2 feet 11⅓ inches stroke. For the heating of the blast fifteen Cowper stoves are used, five stoves being fitted to each furnace. The diameter of the stoves is 19 feet 8 inches, and the height is 98½ feet. The steam necessary for driving the remainder of the blowing engines is generated in twenty boilers with a total heating surface of 16,900 square feet, and fired with blast-furnace gas; particulars are given further on. The gases are cleaned in towers erected immediately behind the furnaces, and the gas after cleansing contains

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When the inspection of the works was completed a return was made to the attractive building already alluded to, and there a second luncheon was provided. During the repast Mr. Gerhard Meyer, in a few felicitous words, stated how gratified they were to welcome a body of British fellow-craftsmen there; whilst Mr. Saniter, in acknowledging, set forth *seriatim* the many interesting and novel things he had seen, and emphasised various instances where both appliances and practice were better than in our own country. He particularly complimented the hosts of the day on the tasteful decorations of the room they were in and of other buildings. Both the vote of welcome and that of thanks were received with warmth and song, until the cry of train drew the members reluctantly away from their kind hosts.

EXCURSION TO THE SAAR DISTRICT AND TO LUXEMBURG.

The members who found leisure to visit the distant districts of Saarbrücken and Luxemburg were about fifty in number. The party assembled early on September 7 at the Düsseldorf Station, and included, besides Mr. G. J. Snelus, Vice-President, the following members:—Professor H. Bauerman, Woolwich; H. M. Butler, Leeds; A. Bannister, Leeds; G. Bermond, Le Creusot; C. Campbell, Spennymoor; A. J. Charlton, Manchester; W. J. Charlton, London; P. Cuinat, Unieux, France; W. Deighton, Leeds; N. Downing, Stockton; C. Fera, Savona, Italy; H. G. Graves, London; W. Hanson, Stockton; A. P. Head, London; J. Henderson, Frodingham; W. Hiby, London; G. T. Jones, Middlesbrough; J. Law Smith, Parkhurst; C. R. Lee, Sheffield; G. C. Lloyd, London; T. B. Mackenzie, Motherwell; B. McNeill, London; G. J. Mair, Millom; A. C. Meyjes, London; F. C. Moorwood, Sheffield; B. Nickel, Duisburg, Germany; F. W. Paul, Tamworth; E. V. Pehrson, Bofors, Sweden; H. Pilkington, Chesterfield; H. J. Preston, Kettering; J. Proctor, Lilleshall; George Raine, Newcastle-on-Tyne; John Raine, Newcastle-on-Tyne; J. G. Riddick, Manchester; E. H. Saniter, Middlesbrough; H. S. Smallman, Wednesbury; G. Snelus, jun., Douay, France; C. Spencer, Middlesbrough; J. Summers, Stalybridge; J. Summers, jun., Stalybridge; B. Talbot, Leeds; H. S. Thomas, Llanelly; J. E. Touch, London; E. Tretz, New York; T. Twynam, Leeds; Otto Vogel, Düsseldorf; T. Walshaw, Rotherham; T. W. Ward, Sheffield; S. T. Wellman, Cleveland, Ohio; J. Williams, Newport, Mon.; and R. Williamson, Cockermouth.

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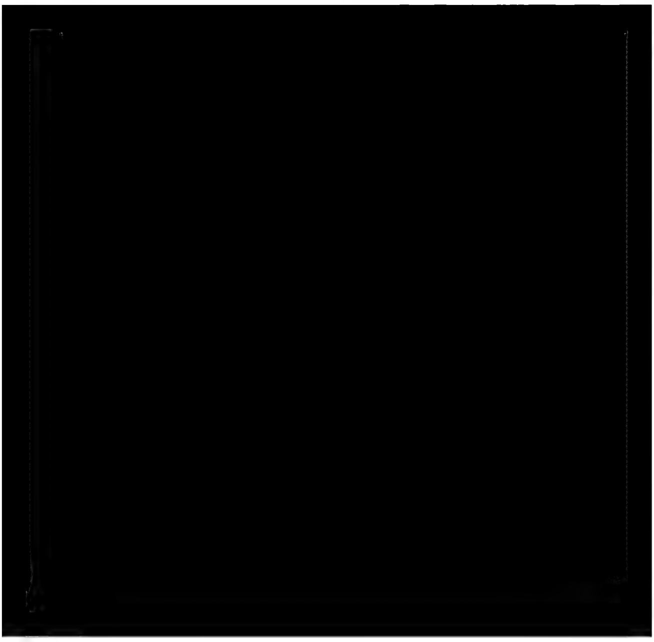
between the gas engines and the fan. The plant has hitherto worked most satisfactorily, and no trouble has been experienced from dust or any other cause.

The blast-furnaces were next visited. Of these there are four at present in blast, all of different dimensions and with an output of from 120 to 230 tons per furnace per day. Basic pig produced from Luxemburg minette, with an addition of Nassau or Russian manganese ore, is the only product blown. When ready for tapping it is run into a ladle and charged direct into the converters. The make of the blast-furnaces being insufficient to supply the demands of the steel works, it is supplemented by imported pig iron, which is remelted in a cupola worked continuously like a blast-furnace and blown with air at 350 to 400° C., the tuyeres and bosh walls being water-cooled. The throat is closed with a cup and cone charger, and the gas taken passes through the washers in common with that from the blast-furnaces. The cupola was started in June 1901 and ran for six months without repairs, the average daily yield being about 400 tons of remelted basic metal. A fifth blast-furnace was blown out in August 1901 after 13½ years' working. A sixth in progress of construction was nearly ready to go into blast, and this formed the principal feature of interest at these works. It is about 100 feet in height and 13 feet diameter in the hearth, 23 feet at the boshes and 16½ feet at the throat, with cup and cone charger combined and a central tube for taking off the gases. Blast is supplied through 16 main tuyeres of 7 inches diameter, alternating with another set of 8 of 4¾ inches diameter placed about 3 feet higher up. The latter are only intended to be used in case of need for removing scaffolds or for other emergencies. The output will be from 250 to 300 tons daily of from 30 to 32 per cent. minette ores. The charge is brought up in skips running suspended on overhead rails, the coke being conveyed direct from the ovens without unloading until discharged at the furnace top. A vertical hoist is used to convey all the materials to the top and a separate electric lift is fitted for the use of workmen. Easy access to all stages of the furnace is afforded by means of platforms and step-ladders. The gas cleaning arrangement is elaborate, a large vertical dust-catcher being placed immediately above the top of the furnace, which separates the heavier suspended material and returns it to the furnace; the current then divides over two downcomers on either side, and, after passing through scrubbers, is forced by two electrically driven fans through cooling and drying towers. Another tandem blast-furnace gas engine of 600 horse-power was

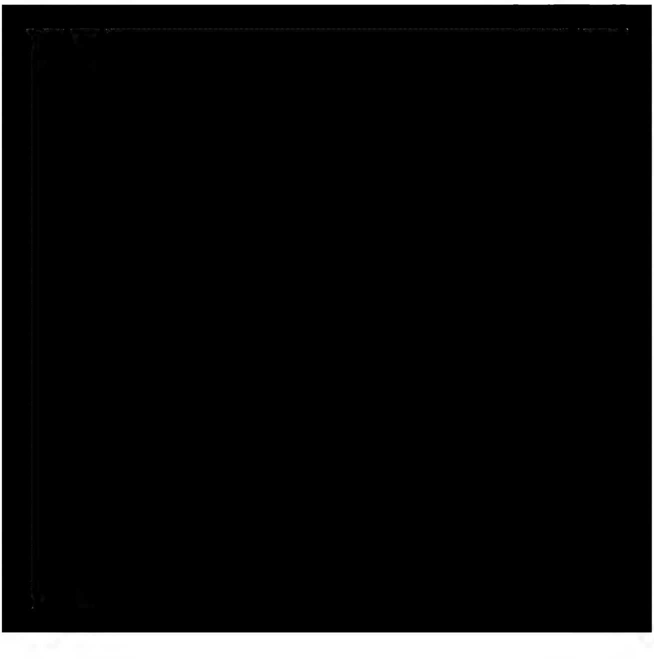


of Mr. Althans, Mr. Vowinkel, and Mr. Bellinger, but before starting on the underground journey a full explanation of the character of the seams and the method of working was given by Mr. Althans, and translated into English by Professor Bauerman. The Saarbrücken coalfield is remarkable as being practically in one ownership and worked entirely by Government officials on behalf of the State. The area is about 688 square miles, and is divided into twenty-four separate mines, the supreme management being with the Mining Direction Board at Saarbrücken, of which Mr. Hilger is president. The aggregate output of all the mines for 1901 was 9,376,000 tons, the Gerhard group giving about 1,130,735 tons. About 90 per cent. of this is raised from the two principal seams, Beust and Heinrich, in the upper flame coal series at a depth of 380 yards, and is sent away without other preparation than hand picking. Coal-cutting machinery driven by compressed air is largely made use of in getting the coal. The Eisenbeiss machine and a machine by Fröhlich & Klüpfel were shown at work. These are mounted on standards, and their output is considerably more than that of the machines carried on a frame, of the Ingersoll-Sergeant and Bechem & Keetman type, of which some are also at work in the mines. The journey made through the workings was about one and a quarter hours. The stables with accommodation for 100 horses were visited, and the cleanliness and orderliness were everywhere much admired. A few members who remained on the surface examined the winding engines and central condensing plant, and a further entertainment was provided in the shape of a fire-call, when the brigade with pumps and hose reel turned out to extinguish an imaginary fire in the office buildings. When the whole party had reassembled in the offices an excellent dinner was served in accordance with the hospitable custom of the district.

At three o'clock the carriages were again in readiness, and the guests were driven in long procession through a picturesque wooded district to Louisenthal, stopping a few minutes on the way to inspect the baths, kitchens, and mess-room for the miners of the Josepha Colliery.

The Burbacher Hütte.

At Louisenthal a number of special tramcars were in waiting to take the party on to Burbach, where the object in view was to visit the Burbacher Hütte. Here they were received by the managing director, Mr. Weissdorf, and other members of the staff, and were



heat of the ovens is utilised in 32 boilers with nearly 100,000 sq feet of heating surface. On completing the tour of the works, party adjourned to the works' casino in the village, where refr ment was served, after which they proceeded by electric tram ca Saarbrücken.

The Saarbrücker Gusstahlfabrik.

At the invitation of Mr. E. G. Sehmer, of Saarbrücken, an alterna visit was arranged on Monday, September 8, to the Saarbrücken C steel Works and to the engineering works of Ehrhardt & Sehme Schleifmühle, Saarbrücken. On reaching Burbach the party divi and those members who had expressed their desire to see the al works were accommodated with carriages kindly provided by Mr. Seh Mr. Hansen, the managing director, received the guests and accompa them, first, into the foundry, where the casting of open-hearth s direct into moulds was in process. A casting ladle of some 20 capacity was suspended from an electric travelling crane and brou into position successively over each mould, the operations being exec with singular swiftness and precision. The next department was for dressing and cleaning the castings, and here an inspection of various products again showed the degree of excellence to which branch of steel-foundry work has been brought in Germany. Nei the surface nor the machined parts exhibited what could be term flaw or a blowhole. Every kind of casting, from light electric fitting to the heaviest spur-wheels, marine-engine bedplates and stern-p was in process of casting and dressing. The works are quite mod and electric power is the sole driving agent employed, being genera at a central station situated within the works. Pneumatic tools hoists are largely used, and the air pressure is supplied by large ele cally driven air compressors.

Ehrhardt & Sehmer, Saarbrücken.

On leaving the cast-steel works the party were driven further to engineering works of Ehrhardt & Sehmer, where they were received Mr. Sehmer, who personally conducted them over the works. Th comprise an iron foundry and pattern shop, and extensive fitting erecting shops, forges, &c. Engineering work of the heaviest descript is carried on here, and the works are equipped with powerful elec cranes, heavy lathes, and all kinds of the most modern machine to

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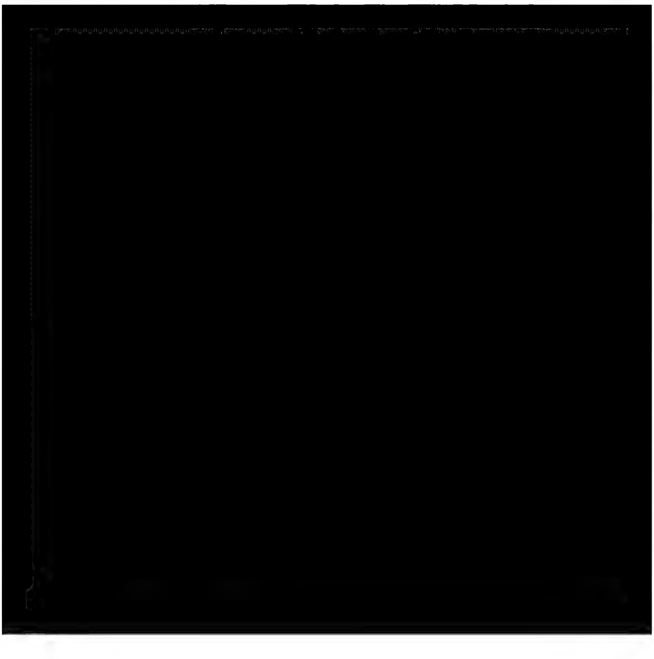
a 200 horse-power gas engine, which also supplies blast to the blast-furnaces. A new felspar jig coal-washing machine has just been erected, capable of washing 60 tons per hour. It had not been put into operation at the time of the visit, but was running idle for the benefit of the members. An older plant for dealing with 40 tons per hour also exists. Owing to the peculiar character of the Saar coal the treatment of it in preparation for coking is quite different from that of the Westphalian coal. Alongside of the two coarse coal jigs is placed a washing box for the coarse shale. The shale is broken up here and is washed in eight small coal felspar jigs along with the pea coal (about 0·4 inch mesh) and the sediment from the coarse coal jigs. The whole of the coal is washed down along troughs into three tanks, from which it is raised by three elevators which drain the coal and deliver it into three disintegrators. These are driven at a very high speed in order to grind the coal as small as possible. The shale is also carried away in elevators in the same way. The washing water is clarified in a number of settling tanks, from which the sludge is from time to time drawn off and mixed with the clean coal. The extra work involved in washing these coals is apparent from the great amount of power expended in driving the plant. A compound engine of 600 horse-power, with an 18 feet fly-wheel and a belt 3 feet 3 inches wide, supplies the required power.

There are six blast-furnaces, with an aggregate daily production of 435 tons. The newest is 78 feet high, 10 feet 6 inches across the hearth, 20 feet 6 inches at the boshes, and 13 feet at the throat, with a daily yield of 130 tons. Seventeen Cowper stoves serve to heat the blast, which is supplied by three compound and one single cylinder engine, and also by the coke-oven gas-driven engine. A 600 horse-power double-acting Korting engine is in course of construction.

The Bessemer works convert forty charges of 12½ tons each in every shift. Of the pig iron half is charged liquid from the blast-furnace and half is remelted in cupolas, using 6·4 per cent. of Westphalian coke. The cupolas are kept at work alternately for one week.

The visitors passed rapidly through the rolling-mill department, where a large girder mill was at work driven by a three-cylinder engine, the first of its kind built in Germany, in 1882. Rather more time was spent in looking at the wire-rod mill, in which 3-inch billets were being rolled in a continuous looping mill, at the rate of 35 tons in twelve hours, the rods being wound on horizontal reels. The rail mill is three-high and all the lifting is done by hand, the men working with



with an incline of 1 in 50. Manganese ores from Poti are also used, and the coke is imported exclusively from Germany. There are at present five blast-furnaces in operation. A sixth has been rebuilt and is shortly to be blown in. Four of these make 110 tons of pig iron daily, while the fifth yields 160 to 170 tons. Two are closed by means of Parry cones, with opening and closing gear operated by steam. The others are fitted with Langen bells, three being operated by hand and one by electricity. The gases are passed through dust catchers and vertical tubing, and serve to heat the boilers and Cowper hot-blast stoves. The largest furnace has a central gas take-off and a washing apparatus formed of two fans for the gases, and these are also used for raising steam and in the stoves. The latter in consequence run five times as long as the other stoves, using gas which has not been freed from dust. A part of the gas from the same furnace is also utilised in driving two gas engines of 500 horse-power, and two others of 1200 horse-power, all supplied by the Deutz Gas Engine Company. The gases after leaving the fan are forced through scrubbers filled with coke and wood shavings, and in this are cleaned effectually. The motors serve to drive electric dynamos only. Five compound engines of 500 horse-power and one of 900 horse-power supply the blast.

The make of these furnaces is exclusively Bessemer metal, the whole being converted into steel in the adjacent Bessemer works. The metal is first carried in a 10-ton ladle and tipped into a mixer, of which there are two, each of 150 tons capacity. From these the metal is poured into a second ladle, which is drawn along to the converter platform by an electric winch. The converters are six in number and have a capacity of 10 to 15 tons. They are arranged in the ordinary way, and the pits are served by hydraulic ingot cranes. The converter linings and bottoms are made from dolomite brought from the Moselle valley, which is burnt in three cupolas in a shop adjacent to the steel works. The necessary grinding and mixing plant, moulding presses, &c., are driven by an electro-motor of 110 horse-power.

The ingots before rolling are placed in Gjers pits, and on withdrawal from these are laid on tilting cradles, which deposit them on the live roller train of a two-high cogging mill. The rolls are of cast steel, 4 feet in diameter, and are driven by a horizontal double-cylinder engine of 2500 horse-power. The blooming mill is three-high, with lifting tables, and is driven by a vertical single-cylinder condensing engine of 1000 horse-power. The daily output of this mill is 600 tons. The large girder and rail mill is two-high and is driven by a three-cylinder

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and delivers them to a shoot to load them on to railway trucks. The moulds are whitewashed to prevent the pigs from sticking. The principal works of this company, which were, however, not visited on the present occasion, are near Aix-la-Chapelle in Germany. They date from 1845, when they were laid out on a very small scale. These now cover 230 acres, while the works at Esch, acquired in 1892, occupy nearly 350 acres. The company also own large mining properties in Luxemburg and Lorraine, which are connected with the railway by eight miles of narrow-gauge railway. Luncheon was afterwards served in the Town Hall, at which Mr. Metz and Mr. Mayerisch, the director of the Dudelingen Works, presided.

The Differdingen Iron and Steel Works.

In the afternoon of the same day the members proceeded further by train to Differdingen, to inspect the fine works of the Deutsch-Luxemburgisch Bergwerks- und Hütten-Aktiengesellschaft. The managing director, Mr. Max Meier, received them, and personally conducted the tour of the works—one of the best arranged of modern plants in Europe. The whole of the blast-furnace plant is arranged in straight lines, the ore yards being in the rear. Then follow the coke-lines, and the row of stoves and blast-furnaces. In front of these again is a sunk road for the slag and metal ladles, spanned by bridges, across which runners are led; and beyond this ladle-road are the covered pig-beds. There are four furnaces, each pair being worked by nine stoves, of which one is kept in reserve. The hot metal is taken to the mixers in ladles, which are lifted to the level of the charging-platform by a hydraulic hoist. There are two 300-ton mixers, one of which is kept under repair while the other is at work. They are tilted by a hydraulic engine, and rock on a pin joint placed underneath. The ladles from the mixer run on a level track to the Bessemer house, which contains four 16-ton basic-lined vessels placed in line, two of which were at work. An additional floor above the converters is supplied with lime by an electrically-driven rope-tramway, and all the lime used is shot into the turned-up converter from this floor. The casting-pit is between the converters and the soaking pits, and is in line with the former, the metal being conveyed to them in an electric ladle-crane and poured into ingot moulds standing on bogies. The soaking-pits are large enough to take four ingots, and have hydraulic pullers for moving their covers.

The cogging mill for roughing out the sections for heavy girders for

engines. Three are coupled direct to dynamos with an intermediate fly-wheel in each case. These generators are made by Schuckert & Co. to give 1140 amperes each at 300 volts when running at ninety revolutions. The other six engines are used to drive air-compressors for supplying the blast to the blast-furnaces, the air cylinder being placed tandem to the gas cylinder and in the rear of it. The engines are all of the Delamare-Deboutteville or Delamare-Cockerill type, and five of the compressors are fitted with the Cockerill self-acting valves, the sixth having mechanically worked valves, by Breitfeld, Danek & Co.

After a brief inspection of the Uehling casting machine the members assembled in one of the casting houses, where an excellent cold collation had been prepared on the pig-bed, converted for the occasion into a banqueting hall, and tastefully decorated with flowers and rockwork. Mr. Max Meier, the managing director, on behalf of his company, expressed the pleasure it had given him to show the works to the visitors, and to this Mr. Snelus, vice-president, suitably replied, thanking him for the cordial welcome they had experienced. With the return to Luxemburg in the evening the programme of this autumn meeting was completed, and the next morning the members broke up to make their way homewards.

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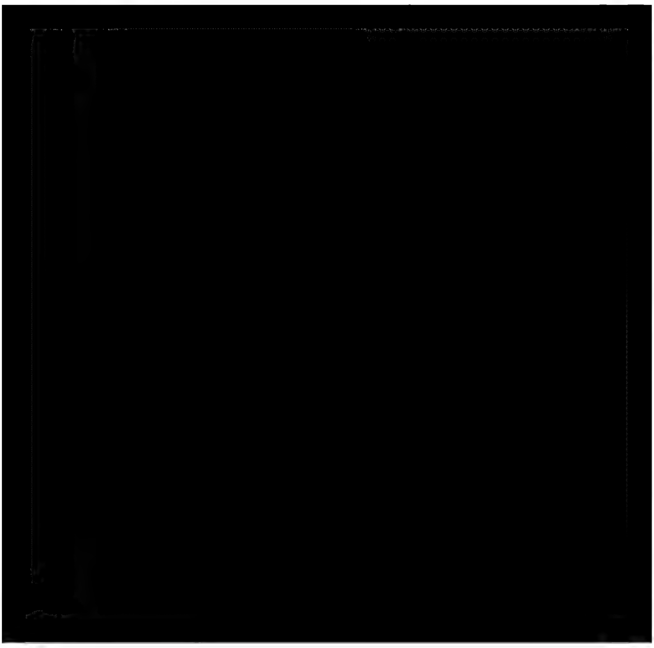
occurrence and the rapidity of its transmission. The latter, he showed, might, in the case of wet gun-cotton, rise as high as four miles a second. The construction of electric and other fuses also engaged his attention, and his knowledge of blasting powders and methods of blasting was of great advantage to the Royal Commission on Accidents in Mines, of which he was appointed one of the scientific members at its constitution in 1879.

On the subject of the flash point of petroleum he rendered useful service, the result of some years' investigation being the legalisation in 1868 of his open-test apparatus; and later, when this proved insufficient, the close-test instrument was evolved and legalised in 1879, and has since continued the standard. In 1883 he was nominated an honorary life member of the Institution of Mechanical Engineers, having in 1881 undertaken, for their research committee on the hardening of steel, experiments on the condition in which carbon exists in steel. The final report, presented in January 1885, showed that the investigation had been carried as far as then seemed practicable by chemical research alone; and the subject remained in abeyance until 1891, when the alloys research undertaken for the same Institution by Sir William Roberts-Austen was found to offer a means of attacking it afresh from another side.

In 1887, Sir Frederick Abel became organising secretary of the Imperial Institute. He was made a Companion of the Bath in 1877, was knighted in 1883, created a Knight Commander of the Bath in 1891, and made a Baronet in 1893, after the opening of the Imperial Institute, while in 1901 he was created a Knight Grand Cross of the Victorian Order. He was a Fellow of the Royal Society, D.C.L. of Oxford, B.Sc. of Cambridge, and an Honorary Member of the Institution of Civil Engineers. He had been President of the British Association, of the Chemical Society, of the Institute of Chemistry, of the Society of Chemical Industry, and of the Institution of Electrical Engineers, and had also been Chairman of the Society of Arts. He held the Albert, the Royal, and the Telford medals. He was almost as active in the study as in the laboratory, and published several books, principally associated with explosives.

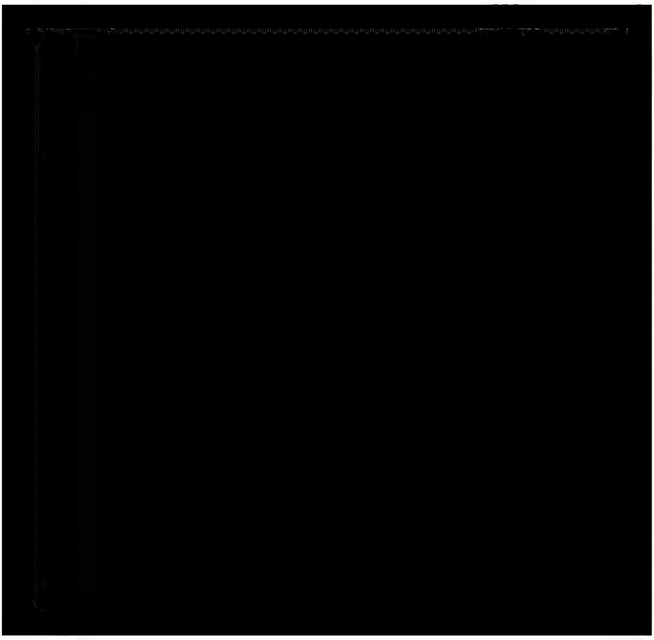
The Iron and Steel Institute has benefited no less than the other institutions with which he was connected from his energy and public spirit. He was elected a member of the Iron and Steel Institute in 1878, became President in 1891, and was awarded the Bessemer Gold Medal in 1897. He delivered masterly presidential addresses in



did not prevent his carrying on a long series of metallurgical researches, of which the most elaborate dealt with the structure of alloys. The Royal Society's Catalogue of Scientific Papers records that he published some two dozen papers, for the most part singly, but occasionally in collaboration with Sir Norman Lockyer, Mr. F. Osmond, or Dr. Alder Wright. They deal with the spectroscopic characters of alloys, the structure of metals, the connection between the properties of metals and the periodic law, and the occlusion of hydrogen by palladium and by electro-deposited iron. In 1889 the Alloys Research Committee of the Institution of Mechanical Engineers was appointed. Roberts-Austen acted as reporter to the Committee, and practically carried out all the tests; and no one who heard him in successive meetings expounding the difficult problems associated with the chemistry and microstructure of metals could fail to appreciate his enthusiasm and ability. This Committee has made five reports, and a final report has, it is believed, been left in draft form.

As a lecturer he possessed unusual gifts. His researches on the diffusion of solid metals formed the subject of his Bakerian lecture to the Royal Society in 1896. His lectures to the Royal Institution, to the Society of Arts, and to the British Association were much appreciated. His last public lecture was the James Forrest lecture at the Institution of Civil Engineers on April 23, 1902. He had great sympathy with artistic work, and read papers before the Society of Arts on alloys in art metal work. He was the author of an "Introduction to the Study of Metallurgy" (London, 1st edition 1891, 3rd edition 1894, 4th edition 1897, 5th edition 1902), which has been characterised as a masterly guide to a knowledge of the principles on which the art is based.

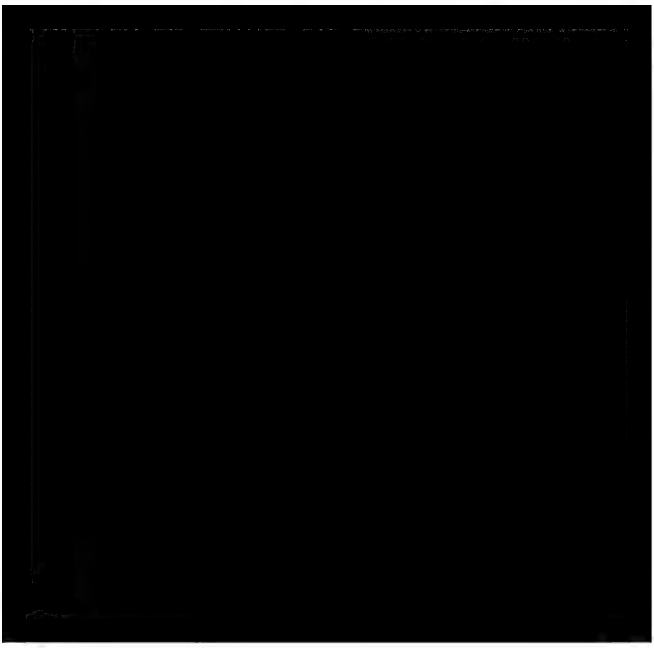
Roberts-Austen rendered service on several Government committees. In 1893 he was chosen to act as chairman of a committee appointed to inquire into the laboratory arrangements of the Customs and Inland Revenue Departments. In the same year he served on a committee, appointed by the Secretary of State for India, to consider the best means of utilising for metallurgical purposes the water-power available on the completion of the Periyar waterworks. In 1896 he was a member of the Board of Trade Committee appointed to consider the cause of the deterioration of steel rails in ordinary use. In connection with the committee, he conducted an elaborate research, and furnished a report of great industrial importance. In 1897 he was directed to serve on a committee appointed to consider the desirability of establishing a National Physical Laboratory; and in 1900 was chosen as a member of



of research to the Institute, and it was from his hands that the Bessemer medal was graciously accepted by Her Majesty, Queen Victoria. The President's reception at the Royal Mint to the members of the Institute, and the dinner given by him to the Council during the Paris meeting, were amongst the pleasantest of the social functions connected with the work of the Institute.

He was buried at Canterbury on November 27. A memorial service was held the same day in the Chapel Royal of the Tower of London, and was attended by numerous friends and by representatives of the Iron and Steel Institute, and of the other societies with which he was connected. A memorial service was also held at the beautifully decorated mission church which he had erected near his house at Chilworth in Surrey, in which, as diocesan reader, he was wont to minister nearly every Sunday.

SAMUEL RADCLIFFE PLATT died on September 5, 1902, at Bangor, in his fifty-eighth year. He was chairman of the Board of Directors of Messrs. Platt Bros. & Co., Ltd., Hartford Works, Oldham, Lancashire. The company have large textile engineering works, ironworks, and collieries, and the extent of the deceased gentleman's business connections and responsibilities may be gathered from the fact that at their works, which cover over 60 acres, nearly 20,000 people are employed. In addition to the Oldham works the company own extensive collieries at Moston and Shaw. Mr. Platt's early practical commercial training was specially adapted to fit him for a business life. At the age of eighteen, after having been educated at Cheltenham College and on the Continent, he entered his father's works. His object was to obtain a thorough knowledge of engineering, and accordingly he went through the various shops of the establishment which bore his name. He subsequently made a special study of machinery construction in various parts of the world. His first extensive travels were in India, in 1865. During the following year he visited America, and on returning in 1867, he went to the Paris Exhibition, taking charge of the firm's exhibits of machinery. In 1869 he paid a visit to Russia, and in 1870 went a second time to America, Mr. F. Platt, his brother, being his companion on this tour. In 1875 he cruised to Madeira and the coasts of Africa in a yacht called the *Camilla*, the predecessor of the *Norseman*, which he purchased in the following year, when he sailed to America again. Such a high opinion had he won by his industry and knowledge of the business that in 1867, when the firm was turned into a limited liability company, he was appointed director, and when his father, John Platt, died in 1872,



member of the firm of Arrol's Bridge and Roof Company, Limited, Glasgow. He was a member of the Institution of Mechanical Engineers, and was elected a member of the Iron and Steel Institute in 1885.

James Barrow died on September 30, 1902, at the Queen's Hotel, Chester, at the age of sixty-five years. Mr. Barrow, who came from North Lancashire to South Wales in the early sixties, was at first manager of three collieries at Maesteg, owned by Messrs. Brogden, namely, Tywith, Cwmdu, and Garth. Messrs. Brogden bought the Tondu ironworks, and eventually became the principal proprietors of the Llynvi ironworks and collieries. Mr. Barrow then became the chief mineral agent of the company at Maesteg, Tondu, and Ogmore, and had continued in this position for several years. He was a leading spirit in all public movements in the district, and was for a number of years a member of the Glamorgan County Council. He was also a member of Council of the South Wales Institute of Engineers. He was elected a member of the Iron and Steel Institute in 1880.

Peter Brotherhood died at his residence, 15 Hyde Park Gardens, on October 13, 1902, at the age of sixty-five years. He was born at Maidenhead in 1838, the son of Rowland Brotherhood, railway contractor, of Chippenham, Wilts. Having passed through a four years' applied science course at King's College, he received a practical training in several engineering works, including the Great Western Locomotive Works at Swindon, and Messrs. Maudslay, Sons, & Field's marine engineering establishment at Lambeth, and began business on his own account in 1867, his present works by the riverside near Westminster Bridge being opened in 1881. It was in 1872 that he invented the special engine with which his name has since been identified. It has three cylinders set at angles of 120° round a central chamber, and all three connecting rods operated upon one crank within the central chamber. When exhibited at the Vienna Exhibition in 1873 it aroused great interest, and its first application as a steam motor was for driving dynamos and also centrifugal pumps in the French warship *Richelieu*. The Woolwich authorities recognised that, if arranged for working with compressed air, it would be greatly superior to the ordinary vertical oscillating cylinder engine then in use in Whitehead torpedoes, the new motor admirably accommodating itself to the limited and circular section of the torpedo. The first Brotherhood three-cylinder air engine

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masters' weekly meetings at Birmingham. He was a Justice of the Peace for Staffordshire, but took no active part in public affairs. He was elected a member of the Iron and Steel Institute in 1883.

WILLIAM HUDSPITH died on November 23, 1902, at his residence, Greencroft, Haltwhistle, Northumberland, at the age of seventy-seven. In early life Mr. Hudspith acquired the South Tyne Brick and Pipe Works and became joint owner of large brickworks and collieries elsewhere. He obtained a large interest in the iron and steel industry at Workington and Maryport, and took part in the formation of the Solway Hæmatite Iron Company. He was also a director of the Moss Bay Works and of the West Cumberland Storage Company, and chairman of the Haltwhistle Gas Light Company. He took a keen interest in agriculture, and as chairman of the technical education committee of the Northumberland County Council rendered valuable services. He was elected a member of the Iron and Steel Institute in 1880.

HIS EXCELLENCY FRIEDRICH ALFRED KRUPP died at Villa Hügel, near Essen, on November 22, 1902, in his forty-ninth year. He was born on February 17, 1854, and being of a delicate constitution, he as a youth made long journeys to strengthen his health, subsequently spending his winters abroad in Egypt, and of recent years in the island of Capri. When his father's death, in 1887, placed him at the head of the establishment, he found himself surrounded by a board of directors, men of conspicuous ability, who helped him efficiently in ruling the vast army of workmen and the little state of now 150,000 people indirectly dependent upon the firm. The extraordinary development of his works since 1887, the elaborate arrangements made for the welfare of his officials and workmen and for their children, and his unlimited benevolence are matters of common knowledge. He was a life member of the Prussian Upper House and a member of the Imperial Diet from 1893 to 1898. Highly sensitive, reserved, and modest, he was anxious to avoid publicity, and successfully escaped the notice of the Press until his ardent support of the Imperial naval schemes exposed him to unscrupulous attacks from the Socialist party. Like his father, he refused the patent of nobility. He was, however, the recipient of numerous decorations, and as a Privy Councillor was entitled to the predicate of Excellency. He married in 1882 Baroness von Ende and leaves two daughters.

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√ Benjamin Martell died on July 15, 1902, at his residence, The Briars, Lee Road, Blackheath, at the age of seventy-seven years. For more than thirty years he had played a prominent part in the many important changes which have taken place during that period in connection with the development of ship construction in this country. Mr. Martell was born in 1825, and his professional career began at Portsmouth Dockyard, where he served his time as an apprentice. His training there, together with his fortunate association during some of those early years with the late Mr. John Fincham in preparing designs of warships and working out problems for the displacement and stability of vessels, laid the foundations of that technical knowledge which enabled him in after years to fill with so much distinction the important position to which he attained. Mr. Martell joined Lloyd's Register Society in 1856, and in sixteen years, after serving the Society at several of the important shipbuilding centres in the country, was called to the position of Chief Surveyor, which he held until his retirement in 1899. The subject which brought Mr. Martell's name before the general public was the much vexed one of the loading of merchant vessels. In the early seventies Mr. Plimsoll had, after strenuous efforts, succeeded in making compulsory on British shipowners the marking on a vessel's sides of the depth to which she was intended to be loaded, without, however, in any way indicating the position at which the mark might with safety be placed. It was left to Mr. Martell to find a solution of this intricate problem, and this he did in a manner that has been considered to meet admirably the requirements of all classes of the shipping community. The tables of freeboard prepared by him, and issued by Lloyd's Register Society, were adopted with some slight modifications by the Load Line Committee, and in 1890 they were placed upon the Statute Book of the United Kingdom. He was a vice-president of the Institution of Naval Architects, and a member of the Institution of Civil Engineers. He was elected a member of the Iron and Steel Institute in 1879.

Olof Gustav Nordenström died at Åtvidaberg on September 6, 1902, at the age of sixty-seven. From 1878 to 1900 he was Professor of Mining at the Stockholm School of Mines. He was the author of a large number of important memoirs on mining, and did much to advance mining practice in Sweden. He was a member of the Swedish Academy of Sciences, and in 1898 was awarded the gold medal of the Swedish Association of Ironmasters. He was not a member of the Iron

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pursuit of his engineering avocations that the paper he read before the Institution of Mechanical Engineers in January 1860 was possibly his earliest contribution to the literature of the profession. The subject was the Giffard injector for feeding steam boilers, which at that time was attracting special attention. On the announcement of the invention in France, its practical value was promptly recognised by Mr. Robinson, and the manufacture and introduction of the injector were undertaken by his firm. After they had first worked out the details of the sizes and shapes of the conical nozzles, and the relative areas of steam and water passages, one of their engineering assistants was sent to visit all the leading engineering works, with a view to the substitution of the injector in place of the feed pump. When the same subject was discussed five years later, at the Institution of Civil Engineers, Mr. Robinson was able to state that all the new engines on the London and North-Western Railway were made to depend entirely upon the injector for the feed water, and there were no pumps to the boilers. In the following year, 1866, he read a second paper before the Institution of Mechanical Engineers, describing the arrangement of the self-adjusting injector devised by Mr. William Sellers, of Philadelphia. He added that the increase in maximum delivery, due to improvements in the proportions of the injector subsequent to its introduction, had been much more considerable in England than in France; the greater degree of success attained in England, particularly at higher pressures, was to be attributed mainly to the adoption of a larger proportionate section area for the steam cone. To the Institution of Civil Engineers, of which he was elected a member in 1872, he contributed in 1873 a paper on modern locomotives, describing six prominent examples of passenger, goods, and tank engines, designed with a view to economy, durability, and facility of repair; respecting each he gave some particulars of the duty performed and of the cost of repairs. Having been a member of the Institution of Mechanical Engineers from 1859, a member of Council from 1866, and a vice-president from 1870, he was elected president in 1878, and again in 1879. During his presidency he was elected an honorary member of the Société des Ingénieurs Civils de France. It was also during his presidency that the Research Committee of the Institution was established in 1879, for the investigation of mechanical questions. In 1863, when the firm of Sharp, Stewart & Co. was converted into a company, he became vice-chairman and afterwards chairman of the Board of Directors. When in 1888 the business had outgrown the Manchester

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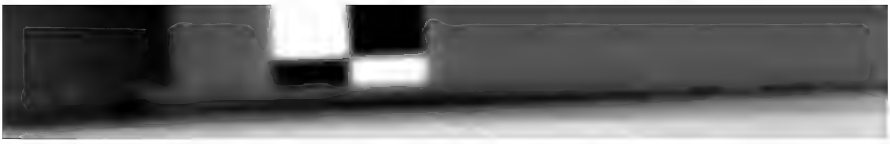
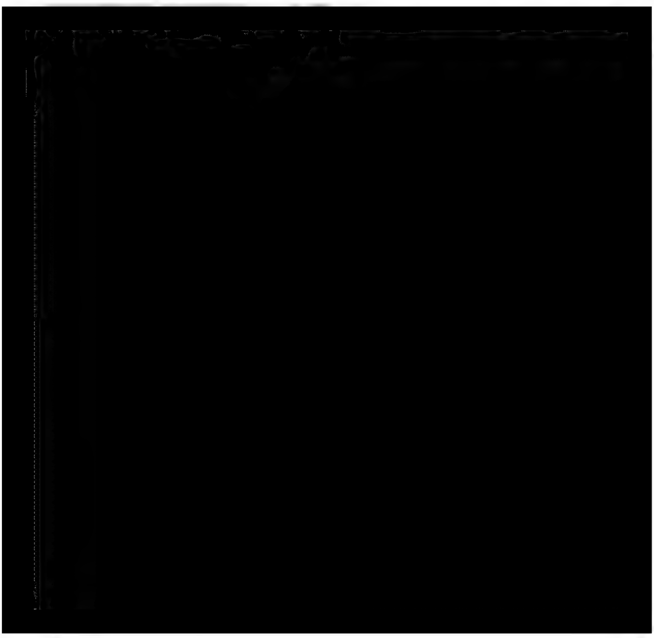
ADDITIONS TO THE LIBRARY

DURING THE SECOND HALF OF 1902

Title.	By whom Presented.
"Programme of the Visit of the Staffordshire Iron and Steel Institute to Coventry, July 16, 1902." Brierley Hill. 1902.	The Secretary.
"The American Invasion." By B. H. Thwaite. London. 1902.	The Author.
"Foreign Import Duties." London. 1902.	The Board of Trade.
"Economising on Steel, Tools, and Fuel." By F. Marsden. St. Petersburg 1902.	The Author.
"Bidrag till Sveriges Officiela Statistik. Kommerskollegii underdånga Berättelse för år 1901." Stockholm. 1902.	R. Åkerman.
"Collection des Monographies." By A. Dory.	The Author.
"Captain Well's Improved Tractor." London. 1902.	W. Lloyd-Wise.
"Annual Report of the Minister of Mines for the Year ending 31st December 1901. Being an account of Mining Operations for Gold, Coal, &c., in the Province of British Columbia." Victoria, B.C. 1902.	The Provincial Mineralogist.
"The Internal Structure of Iron and Steel, with special reference to Defective Material." By S. A. Houghton. London. 1902.	The Author.
"Syllabus of Courses of the University of Birmingham for 1902–1903."	Thomas Turner.
"Mines and Quarries: General Report and Statistics for 1901." Part II.—Labour. London. 1902.	The Under-Secretary of State.
"Crucible Steel; its Manufacture and Treatment." By D. Flather. Brierley Hill. 1902.	The Author.
"Annual Report of the Secretary for Mines and Water Supply for the Year 1901." Victoria. 1902.	Minister of Mines.
"Differential Calculus for Beginners." By A. Lodge. London. 1902.	The Publishers.
"Report and Proceedings of the Mining Conference held at Ipoh, Perak, September 23 to October 6, 1901." Taiping. 1902.	The Resident-General.



Title.	By whom Presented.
"Mines and Quarries: General Report and Statistics for 1901." Part III.—Output. London. 1902.	The Under-Secretary of State.
"Transactions of the Civil and Mechanical Engineers' Society, Forty-third Session, 1901–1902." London. 1902.	The Secretary.
"A Rectorial Address delivered to the Students in the University of St. Andrews, October 22, 1902." By Andrew Carnegie. Edinburg. 1902.	The Author.
"Mysore Geological Department." Report of the Chief Inspector of Mines for the Year 1901. Bangalore. 1902.	The Secretary.
"The Treatment of Steel." Pittsburgh. 1902.	The Crucible Steel Company.
"Rolled Steel Beams." London. 1902.	H. J. Skelton & Co.
"Census Bulletin." Nos. 208 and 246. Washington, D.C. 1902.	W. G. Gray.
"Handbuch der Eisenhüttenkunde." Vol. ii. By A. Ledebur. Leipzig. 1902.	The Author.
"Some Notes on a Visit to Western Pennsylvania in 1902." By Thomas Turner, B.Sc. (Paper read before the Staffordshire Iron and Steel Institute, November 29, 1902.) Brierley Hill. 1902.	The Author.
"Producer Gas; and its Use in Engineering and Shipbuilding." By F. J. Rowan.	C. G. Norris.
"Producer Gas and its Applications." By F. J. Rowan.	C. G. Norris.
"*Via* Eastern." Telegraphic Social Code. London. 1902.	The Company.
"Annual Report of the Department of Mines, Western Australia, for the Year 1901." Perth. 1902.	The Secretary.
"The Designing and Equipment of Blast-Furnaces." By J. L. Stevenson. London. 1902.	The Author.
"Emploi des explosifs dans les mines de Houille de Belgique pendant l'année 1901." By V. Watteyne, S. Stassart, and L. Denoel. Brussels. 1902.	V. Watteyne.
"Metallurgy and its Relationship to the Work of the Founder." By Percy Longmuir. (Paper read before the Manchester and District Ironfounders' Association, October 1, 1902.)	The Author.



Canadian Mining Institute.
Canadian Society of Civil Engineers.
Department of Mines, Melbourne.
Department of Mines, Sydney.
Geological Survey of Canada.
Geological Survey of India.
Geological Survey of New South Wales.
Mining Society of Nova Scotia.
Royal Society of New South Wales.

United States.

Alabama Industrial and Scientific Society.
American Association for the Advancement of Science.
American Foundrymen's Association.
American Institute of Mining Engineers.
American Iron and Steel Association.
American Society of Civil Engineers.
American Society of Mechanical Engineers.
Department of Labour.
Engineers' Society of Western Pennsylvania.
Franklin Institute.
Massachusetts Institute of Technology.
New York Academy of Sciences.
Ordnance Office, War Department.
School of Mines, Columbia University, New York.
Smithsonian Institute.
United States Geological Survey.

Austria.

K.K. geologische Reichsanstalt.
Oesterr. Ingenieur- und Architekten-Verein.

Belgium.

Association des Ingénieurs sortis de l'École des Mines de Liége.
Ministère de l'Intérieur.

France.

Comité des Forges.
"Revue Maritime." Ministère de la Marine.
Société d'Encouragement pour l'Industrie Nationale.
Société de l'Industrie Minérale.
Société des Anciens Élèves des Écoles Nationales d'Arts et Métiers.
Société des Ingénieurs Civils.
Société Scientifique Industrielle de Marseille.

Denmark.

Tekniske Foreningen.

Germany.

Königliche Bergakademie in Freiberg.
Königliche Technische Versuchsanstalt.
Verein Deutscher Eisenhüttenleute. (Journal "Stahl und Eisen.")
Verein Deutscher Ingenieure.

United States.

"Age of Steel."
"American Journal of Science."
"American Machinist."
"American Manufacturer."
"Bradstreet's."
"Cassier's Magazine."
"Engineering and Mining Journal."
"Engineering Magazine."
"Engineering News."
"Iron Age."
"Iron Trade Review."
"Letter of the Anthracite Coal Operators' Association."
"Metallographist."
"Mines and Minerals."
"Railroad Gazette."
"Tin and Terne."

Austria.

"Oesterr. Zeitschrift für Berg- und Hüttenwesen."

Belgium.

"Bulletin de l'Union des Charbonnages de Liége."
"Moniteur des Intérêts Matériels."
"Revue Universelle des Mines."

France.

"Annales des Mines."
"L'Echo des Mines."
"Le Génie Civil."
"Le Mois Scientifique et Industriel."
"Portefeuille Économique."

Germany.

"Annalen für Gewerbe und Bauwesen."
"Chemiker Zeitung."
"Glückauf."
"Verein Deutscher Eisen- und Stahl-Industrieller."
"Zeitschrift für das Berg-, Hütten- und Salinenwesen im preussisc Staate."
"Zeitschrift für praktische Geologie."
"Zeitschrift für Werkzeugmaschinen und Werkzeuge."

Italy.

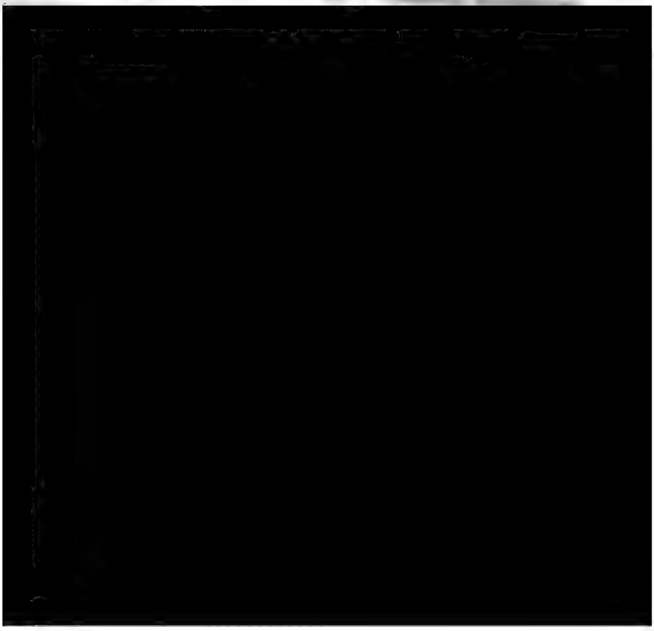
"L'Industria."
"Rassegna Mineraria."

Spain.

"España."
"Revista Minera."

Sweden.

"Teknisk Tidskrift."



IRON ORES.

CONTENTS.

I.—*OCCURRENCE AND COMPOSITION.*

Ore in Sight.—The Council of the Institution of Mining and Metallurgy appointed a committee to consider what steps might be taken in defining the term "Ore in Sight." The views expressed by leading members of the profession showed a great divergence of opinion as to the definition of the term. It was decided : That members of the Institution should not make use of the term "Ore in Sight" in their reports without indicating, in the most explicit manner, the data upon which the estimate is based; and that it is most desirable that estimates should be illustrated by drawings. That as the term "Ore in Sight" is frequently used to indicate two separate factors in an estimate—namely: (*a*) ore blocked out—that is, ore exposed on at least three sides within reasonable distance of each other; and (*b*) ore which may be reasonably assumed to exist, though not actually "blocked out"—these two factors should in all cases be kept distinct, as (*a*) is governed by fixed rules, whilst (*b*) is dependent upon individual judgment and local experience. That in making use of the term "Ore in Sight" an engineer should demonstrate that the ore so denominated is capable of being profitably extracted under the working conditions obtaining in the district.

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Iron Ore in France.—The Haut-Quercy Mining Company has been formed to work iron ore in the department of the Lot and the Dordogne. The ore contains 51·86 per cent. of iron, 0·21 per cent. of manganese, 8·80 per cent. of silica, 0·055 per cent. of phosphorus, and 0·013 per cent. of sulphur. It is mined near Bandiat.*

A geological survey of the ore beds of Normandy has been carried out by R. Masse,† and the results of his investigations are given. The occurrence of extensive deposits of red and brown hæmatite is described.

Iron Ore in Germany.—K. Schlegel ‡ describes the magnetic bed of the Schwarzen Krux near Schmiedefeld in the Thuringian Forest.

Oolitic Iron Ores of Lorraine.—In a paper read before the *Verein deutscher Eisenhüttenleute*, W. Kohlmann § observes that of late years much literature has been devoted to the description of the iron ore deposits of Lorraine, but, as a rule, they have dealt only with one or other portion of these deposits. The author gives a list of 57 such papers, beginning with one by E. Jacquot in 1868. Of these, however, only a short account (published by Hoffmann in 1898) deals generally with the whole iron ore deposit, that is to say, with both the German, Luxemburg, French, and Belgian portions. This want the author endeavours to fill. The elevated plateau of Lorraine, lying between the Vosges and the Argonnes, contains in its western portion deposits of oolitic iron ore known under the name of minette. The consideration of a geological map of this district will show that it chiefly consists of Jurassic beds, with some belonging to Triassic series, which dip generally very gently to the west. The ore deposits themselves are found in a horizon which German geologists consider as Lower Dogger and the French as Upper Lias, although this particular horizon does not always contain iron ore throughout the whole of the plateau of Lorraine. There are two districts in which the ores are found in paying quantities. The northern is that of Briey, while the southern is around Nancy. The first stretches from the region where the frontiers of the four countries meet southwards to a point about 9·5 miles to the south of Metz. From this point, for a further distance

* *Echo des Mines*, vol. xxix. p. 986.

† *Annales des Mines*, 10th series, vol. i. pp. 581-608.

‡ *Zeitschrift der Deutschen Geologischen Gesellschaft*, 1902, pp. 24-55.

§ *Stahl und Eisen*, vol. xxii. pp. 493-503, 554-570, with three sheets and illustrations in the text.

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	Black Bed.	Grey Bed.	Red Bed.	Red Sandy Bed.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Silica	15·1	7·9	9·9	33·6
Ferric oxide . .	57·0	45·5	60·6	44·5
Ferrous oxide . .	0·3	0·4	...	...
Alumina . . .	5·2	2·3	5·5	4·2
Lime	5·9	19·0	6·2	5·3
Magnesia . . .	0·5	0·5	0·5	0·5
Phosphorous pentoxide . .	1·7	1·7	1·8	1·6
Sulphur trioxide .	...	0·1	0·1	0·1
Carbon dioxide . .	4·6	14·3	4·9	4·1
Moisture . . .	9·3	8·0	10·1	6·6

The number of complete analyses of minette which have been published is but very small. The result is that there is but very little knowledge as to the real character of the ore. The author thinks that in addition to the oxides or hydroxides, carbonates, and silicates of iron, frequently complicated iron-alumina silicates and iron-magnesia-alumina silicates, such as thuringite, cronstedtite, and chamosite, occur in minette ores. The author doubts the existence of the iron silico-carbonate which Blum believes he has observed in one of these ores. An analysis of a minette ore can only give useful results if it is accompanied by a microscopic investigation. As a rule, those ore beds which are of commercial value contain per cent. :—

Fe.	SiO_2.	CaO.	Al_2O_3.	P_2O_5.
30 to 40	4 to 20	4 to 20	2 to 8	0·5 to 2·0

The contents of silica and clay are, however, often far more considerable. The silica sometimes exceeds 40 per cent., whilst at other times beds occur in which lime and marl make up 50 per cent. of the whole, the bed itself being then quite valueless as far as its being worked commercially is concerned.

After a general petrographical consideration of the minette beds as a whole, the author proceeds to describe each particular deposit in detail. Seven beds are distinguished as being the chief. These are (1) the red sandy, (2) the red or red calciferous, (3) the yellow, (4) the grey, (5) the brown, (6) the black, and (7) the green beds. The composition of the grey bed in the German ore district is about :—

Iron.	Lime.	Silica.
28 to 40	10 to 15	5 to 10

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Iron Ore in Italy.—A detailed description of the ore deposits of Brosso and Traversella in Piedmont has been published by V. Novarese.* The ore deposits associated with dioritic eruption products are divided into three groups: (1) the magnetite deposits of the Bersella valley west and north of the main diorite mass, (2) the specular iron ore and pyrites deposits of Brosso east of the diorite mass, and (3) the sulphide deposits in fissures in the mica schist. The first of these deposits were worked as far back as 1487. Mining operations have now ceased, but attempts are being made to restart the mines.

Iron Ore in Russia.—W. Tarassenko † describes the magnetite rock met with at Michailowka, in the Winniza district, Podolia, Russia. The rock contains 45 per cent. of magnetite, and differs in geological character from the Krivoi Rog magnetite rock.

A. Schepowalnikoff ‡ describes the ore deposits at Tulomosersk, in the government of Olonetzk. Specular iron ore occurs intercalated between limestones. It is rarely met with in the shale.

A. Krosnopolsky § gives the results of a geological survey of the Bakal iron ore region in the Southern Ural.

J. Morozewicz ‖ describes the Magnitnaja Gora iron ore deposit in the Southern Ural.

Iron Ore in Spain.—L. Mallada ¶ gives a geological description of various iron ore deposits in Spain. Mines in Badajoz, Seville, Cordova, Albacete, Almeria, Guadalajara, Lugo, and Guipuzcoa are dealt with.

R. S. Lozano ** describes the iron ore deposits of the river Ibor in the province of Caceres. The ore contains 46·53 per cent. of iron, 3·24 per cent. of manganese, 1·17 per cent. of sulphur, and 0·16 per cent. of phosphorus. The quality of ore available is, however, not sufficient to warrant working on a large scale.

J. Hereza †† directs attention to the deposits of specular iron ore at Jabugo in the province of Huelva.

A description has been published of the iron ore deposits of the province of Lugo, Galicia, Spain. The ore, which contains 49·31

* *Zeitschrift für praktische Geologie*, vol. x. pp. 179-187.
† *Geologisches Centralblatt*, vol. ii. p. 322.
‡ *Ibid.*, p. 547.
§ *Ann. géol. et min. de la Russie*, vol. v. pp. 109-110.
‖ *Ibid.*, pp. 114-117.
¶ *Boletin de la Comision del Mapa geologico de España*, vol. xxvi. pp. 152-203.
** *Ibid.*, pp. 205-219.
†† *Revista Minera*, vol. liii. pp. 295-296.

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extent and quality, but they are rather out of the way for railway transport. They exist in great beds resting on the Cambrian schists; probably they do not penetrate them. They have given the supplies of ore to a number of Catalan forges for a long series of years. One of these forges is still in activity, making shoeing-iron and nail-rods of excellent quality. The country people, when ordered, go to one or other portion of the deposit, break it out with a simple pick or hoe, load their carts, and take it to the forge, where they are paid so much per quintal for it delivered, costing them nothing but their work. The ore is of a dark brown colour, with a red streak. There will be no blasting in working it, as it is easily broken by the pick, although sufficiently hard not to disintegrate on handling. It averages 56 per cent. iron, with 0·10 of phosphorus.

Due west from Visuna the Incio deposits exist. These are thick lodes rather than surface deposits. Analyses of ore from three of the lodes yielded: 50·24 per cent. iron and 0·10 phosphorus, 56·80 of iron and 0·10 phosphorus, and 55·60 of iron with 0·43 phosphorus. These also supplied Catalan forges for a long period, but their time has passed, and they are now extinct.

F. Illingworth * summarises the present condition and probable future prospects of the iron ore districts of Spain.

F. D. Adams † gives some notes on the iron ore deposits of Bilbao.

Iron Ore in Canada.—F. Hille ‡ deals with the iron deposits of Western Ontario and their genesis, and classifies them as follows: (1) Huronian magnetites and limonites from carbonates found in the Kaministiquia, Matawin, Green Water Lake, Hunter's Island, and Atikokan; (2) Post Huronian magnetites found in Green Water Lake and Head Lake; (3) Cambrian magnetites and carbonates, &c., especially magnetites, at the northern margin of the formation. The first four localities of the first class show extensive deposits of poor and siliceous magnetites averaging 35 to 40 per cent. of iron. The Atikokan ores are capable of being enriched by dressing. The general geological features of these and the other deposits are described, and their formation is ascribed largely to the action of water.

W. Blakemore § describes the iron ore deposits near Kitchener, British Columbia. They consist of five parallel veins running for a

* *Contract Journal*, vol. xlvii. pp. 799–803.

† *Journal of the Canadian Mining Institute*, vol. iv. pp. 196–204.

‡ *Ibid.*, vol. v. pp. 49–61, with maps.

§ *Ibid.*, vol. v. pp. 76–80.

and the resultant saving in freight. The balance shows an economy of 2½d. per ton, or about £100,000 annually. A further advantage of the dried ore would be increased facility in handling and an economy of fuel and in the dust blown out by steam in the furnace. The ore would, however, have to be kept under cover after drying.

The usual long list of cargo analyses of Lake Superior iron ores from the various ranges has been published by the Lake Superior Iron Ore Association.* The limits for the iron percentage ranges between 64·8 and 40.

Alteration of Spathic Iron Ore into Magnetite.—K. Busz † states that at Krupp's Luise mine at Horhausen spathic iron ore is converted into magnetite by contact with basalt, which traverses it in several veins.

Magnetism of Magnetite.—F. Rinne ‡ discusses the disappearance and reappearance of magnetism on heating and cooling magnetite.

Analyses of Iron Ore.—B. Osann § deals with the cost of reduction of a series of iron ores, &c., of some of which the following are partial analyses:—

(1) *Calcined spathic ore from Bilbao.*—Fe, 58; Mn, 1·0; P, 0·015; Al_2O_3, 2·0; CaO, 0·8; MgO, 3·0; S, 0·4; residue, 7·0; H_2O, 1·0.

(2) *Calcined Siegen spathic ore.*—Fe, 42·8; Mn, 8·5; P, 0·01; Cu, 0·18; $SiO_2 + Al_2O_3$, 12·7; MgO + CaO, 3·6; moisture, 9·0. This is run down for spiegeleisen containing 11 per cent. of manganese.

(3) *Pyrites residues.*—Fe, 54; residue, 3·5; Mn, 0·1; P, 0·02; Pb, 0·5; Cu, 0·2; Zn, 0·12; S, 2·0; H_2O, 16·5.

(4) *Dillenburg red hæmatite.*—Fe, 53; residue, 18; Al_2O_3, 2; MnO, 0·6; P_2O_5, 0·6; S, 0·1; H_2O, 3·0.

(5) *Brown iron ore from the Lahn district.*—Fe_2O_3, 58; residue, 12·8; Al_2O_3, 4·4; $CaCO_3$, 3·6; MnO, 1·6; P_2O_5, 0·9; SO_3, 0·25; water of hydration, 6; moisture, 12.

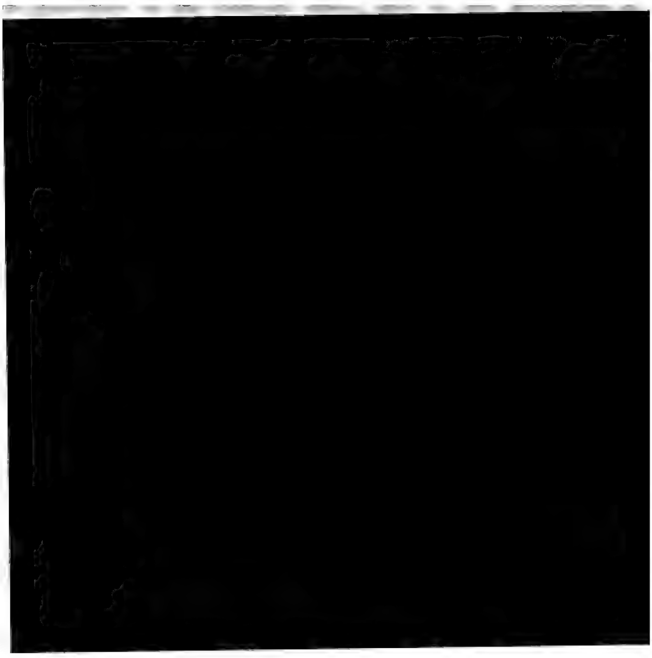
(6) *Upper Silesian brown iron ore.*—Fe, 25; Mn, 1·0; MgO, 0·5; Pb, 0·6; Zn, 1·7; CO_2, 2; H_2O, 33.

* *The Production of Iron Ores in* 1901, pp. 26-30, Washington, 1902; *Iron Trade Review*, April 17, 1902, pp. 36-39.

† *Geologisches Centralblatt*, vol. ii. p. 485.

‡ *Centralblatt für Mineralogie*, 1902, pp. 294-305.

§ *Stahl und Eisen*, vol. xxii. pp. 1106-1110.



the various mines have large outputs, only two winning over a million poods each (say 16,130 tons). Larger undertakings, including two English companies, have lately been started. In general the mines are badly equipped, and as the ore is principally mined for export, nothing containing less than 55 per cent. of manganese is won. More than fifty such manganese ore deposits are known in the Caucasus. In South Russia the manganese mining industry has a better organisation. The ore in the beds is estimated at some 7,400,000 tons. Both deep mining and open-cast are employed, and ore is mined containing from 30 to 50 per cent. of manganese. The four most important mines are in the vicinity of Nikopol. In the Perm district of the Ural the manganese ore deposits are neither numerous nor rich, but in the Orenburg division the deposits are numerous, and they contain large quantities of ore. So far, however, no ore has been mined, as fuel is absent, and no good means of communication exist. The considerable fall in prices which occurred at the end of 1901 and the commencement of 1902, as well as the constantly increasing competition of the Brazilian ore, has placed the manganese ore industry of Russia in a critical position. The ore is not dear to mine, but transport is difficult and expensive, and cheaper transport and greater facilities in this direction are badly needed.

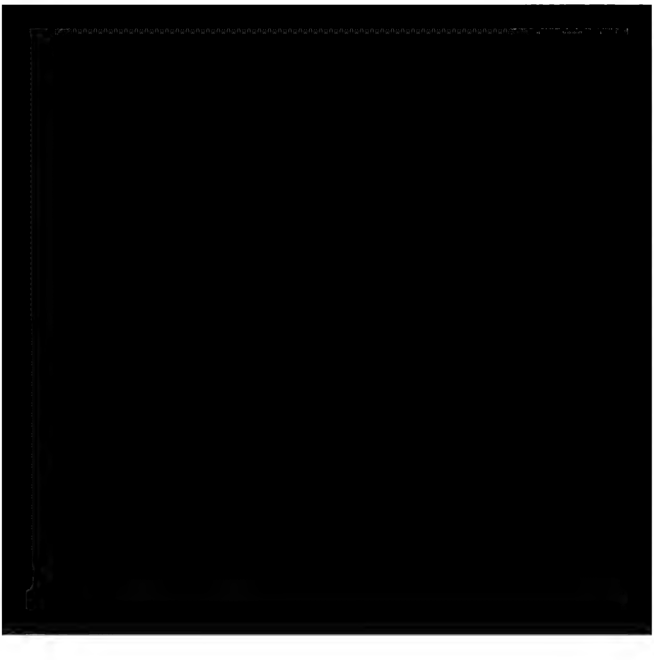
Recent Researches on Meteorites.—A descriptive catalogue, with ninety-two plates, of the meteorite collection in the United States National Museum has been compiled by W. Tassin.*

S. Meunier † directs attention to the false meteorites in the Paris Museum of Natural History. Certain slags, iron pyrites, and iron ores have long been mistaken for meteorites.

The fall of a meteoric stone near Crumlin, County Antrim, on September 13, 1902, is recorded by W. H. Milligan,‡ and some notes on the meteorite are given by L. Fletcher.§ The meteorite, which weighs 9 lbs. $5\frac{1}{2}$ oz., has been purchased by the Trustees of the British Museum.‖

H. A. Ward ¶ gives an account of a visit paid to a meteorite which is estimated to weigh 50 tons, and was discovered in 1876 in the State of Sinaloa, Mexico. It is $13\frac{1}{12}$ by $6\frac{1}{6}$ by $5\frac{1}{3}$ feet in dimensions, and

* *Annual Report of the Board of Regents of the Smithsonian Institution*, pp. 670-698.
† *La Nature*, vol. xxx. pp. 19-22.
‡ *Nature*, vol. lxvi. p. 577.
§ *Ibid.*, pp. 577-579.
‖ *The Times*, November 11, 1902.
¶ *Proceedings of the Rochester Academy of Science*, vol. iv. pp. 67-74.



results of the examination of nineteen irons, with numerous analyses of the irons as a whole, and of the various minerals (cohenite, schreibersite, tænite, amorphous carbon, and cliftonite) isolated from them.

II.—*IRON ORE MINING.*

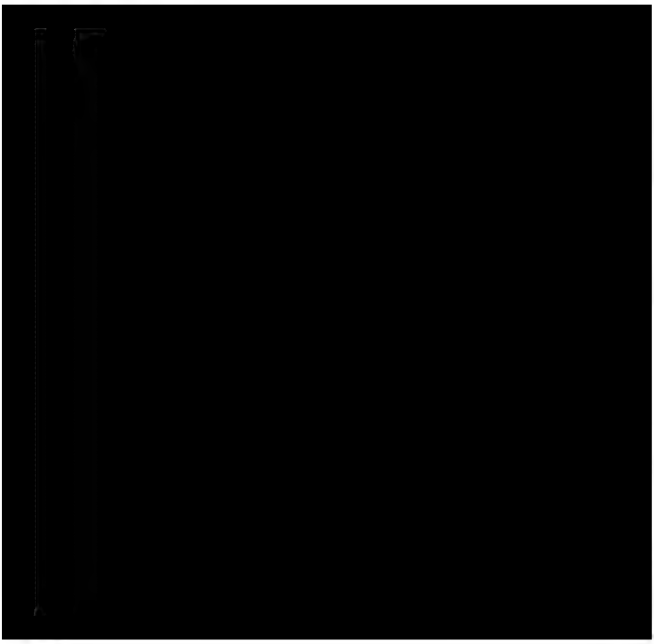
Iron Ore Mines.—W. S. Harwood * gives an illustrated account of mining in the Lake Superior district.

A. W. Robinson † gives an illustrated account showing the marvellous development of the use of the steam shovel for mining iron ore in the Lake Superior district. Ten years ago the ordinary or standard size of machine weighed 35 tons, and carried a bucket of 1½ cubic yard's capacity; now, machines of 90 tons with buckets holding 4 cubic yards are built, and are worked by the same number of men as were required for the smaller sizes, and all the movements are controlled by steam instead of hand levers. The speed attained is four buckets full per minute, and this necessitates eight separate movements on the part of two operators for each load. An average day's work of a good shovel is as much as 2400 loads or 3600 tons, as compared with 4½ tons for a labourer with a pick and shovel. It is estimated that 2000 machines are at work in Canada and the United States. In the Lake Superior district, the steam shovels are used for three classes of work, stripping the ore, digging the ore itself, and loading it into railway waggons, and loading the ore, often in a frozen state, from the stock piles. The cost of handling material is one cent per ton or even less.

H. Nordqvist ‡ publishes the observations made by him on a visit to mines in Germany and Austria. The iron ore mines visited were the following: Hüggel near Osnabrück, Storch at Siegen, Poindwerde at Betzdorf, the Dillenberg and Wetzlar hæmatite mines, the Bergfreiheit magnetite mine at Schmiedsberg, Hüttenberg in Carinthia, and Erzberg in Styria.

Shaft Sinking.—A. Foomis § describes some heavy cast-steel cutting shoes used at the bottom of the timber framing of a shaft being sunk from the surface through quicksand. The shoes are made in segments

* *Pall Mall Magazine*, vol. xxviii. pp. 171-180.
† *Cassier's Magazine*, vol. xx. pp. 608-617.
‡ *Bihang till Jernkontorets Annaler*, 1902, pp. 169-196.
§ *Engineering and Mining Journal*, vol. lxxiii. p. 583.



is wheeled to a dressing-plant, where it is picked and crushed. At present, 50 tons daily are produced.

A historical account of mining in the Caucasus has been published by M. A. Shostak.*

F. Drake † gives an account of the Nicopol manganese ore district in Southern Russia on the Dnieper, 190 miles above Odessa. At present five groups of mines are at work on a fairly horizontal bed of ore ranging from 1 to 6 feet, but averaging 3½ feet in thickness. It lies near or at the top of the Oligocene formation. The ore contains about 27 per cent. of silica, 29·5 to 34·6 per cent. of metallic manganese, and 0·24 to 0·28 per cent. of phosphorus. The ore is worked from adits, being blocked out by galleries, and the blocks subsequently removed. Some of the ore is simply hand-picked, and at other places it is washed.

Handling Iron Ore.—An illustrated description has appeared of the new Brown unloading crane recently installed at the new Krupp works at Rheinhausen.‡ With this apparatus, 500 tons can be handled in 10 hours.

H. Hoffmann § describes the arrangements for transporting and handling minerals shown at the Düsseldorf Exhibition. Special attention is devoted to wire ropes, which were specially well displayed, the firm of J. Pohlig having in their own pavilion an interesting series of drawings of wire ropeways. They had also a complete plant in operation.

F. Bardelli ‖ describes the more important aerial wire ropeways installed in various parts of the world by A. Bleichert & Co.

An article has appeared ¶ describing and illustrating the Bleichert wire ropeway system and the method of operating it. Over 1500 of these ropeways have now been installed, with an aggregate length of 1000 miles. In some cases the span of the rope from support to support is upwards of 1100 yards. Six miles is about the maximum length of a single section without an intervening station. From 200 to 250 tons per hour can be transported by such a ropeway.

* *Mining Journal*, vol. lxxii. pp. 1275–1276.

† *The Mineral Industry*, vol. x. pp. 447–455.

‡ *Glückauf*, vol. xxxviii. pp. 901–906.

§ *Ibid.*, pp. 773–786.

‖ *Rassegna Mineraria*, vol. xvii. pp. 19–24.

¶ *Zeitschrift des oesterreichischen Ingenieur- und Architekten-Vereines*, vol. liv. pp. 619–622.

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REFRACTORY MATERIALS.

Fire Clay.—H. Ries * thinks that a material should not be considered refractory unless its melting-point lies above 2700° F., but admits that a satisfactory definition of a fire clay is difficult to formulate. The "plastic" fire clays include ordinary clays and shales which become plastic after grinding with water, while the "flint" clays do not develop plasticity. The refractoriness of clays depends on their composition and on their fineness of grain, though some authorities contradict the latter assertion. The percentage of fluxing materials is usually low, rarely exceeding 4 to 5 per cent., but their action is variable, and is usually greater if they are finely disseminated. The effect of titanium, which is often present, is usually negligible. Shrinkage is often in close agreement with the plasticity, and the high silica materials often expand in burning. Fire clays are worked underground or in open workings; in the latter case the steam shovel is sometimes employed. The geological and geographical distribution is then considered, and a short *résumé* is given of the deposits in the different states of the United States. The manufacture of fire bricks is then shortly considered, and a review of the literature of clay and clay products is given as an appendix covering some eight pages.

Quartzite.—Baron L. Rosenberg † has investigated samples of quartzite from the governments of Charkov, Ekaterinoslav, Kherson, Tauria, and the region of the Don Cossacks, and finds that many of the quartzites are well adapted for the manufacture of Dinas fire bricks.

Magnesite.—Some illustrations have been published ‡ to show the magnesite quarries and works at Stronghili, Moraiti, and Archangelos

* *The Mineral Industry*, vol. x. pp. 108-124.
† *Rigasche Industrielle Zeitung*, 1901, No. 17.
‡ *Iron and Coal Trades Review*, vol. lxv. pp. 532-533.

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Bauxite.—A. W. Evans * describes the mining of bauxite at Harrisburg, Georgia. The mineral is worked open-cast and taken in side-tipping trucks to the washer, which is of the double-log type, with inclined 12-inch logs carrying spiral teeth. The washed material is treated in a rotary drum drier 3 feet in diameter and 35 feet in length, with a fall of 6 inches in its length. Small cups are spirally arranged inside the drum to turn the material over and to urge it forward.

C. W. Hayes † describes the Arkansas bauxite deposits.

C. Formenti ‡ states that samples of genuine bauxite have been found in the province of Aquila in Southern Italy. The results of the physical and chemical examinations are given. The percentage of alumina present in the specimens varies from 51·13 to 57·52.

* *Mines and Minerals*, vol. xxii. pp. 481–482.

† *Twenty-first Annual Report of the U.S. Geological Survey*, Part III. pp. 473–485.

‡ *Gazzetta chimica italiana*, vol. xxxii. pp. 453–461; *Journal of the Chemical Society*, vol. lxxxii. p. 569.

The method of using the Mahler-Kroecker bomb-calorimeter is described by J. Wolfmann.*

Calorific Value of Fuels.—The determination of the constituents of various kinds of coal is considered, and the calorific value of coal, petroleum, ether, and spirit is calculated.†

E. Goutal ‡ stated that, by an examination of 600 different coals, calorific value (P) is found to be given with an approximation of 1 per cent., by the formula $P = 82C + aV$, in which C is the carbon percentage of ash-free coke, V the volatile matter, and a a coefficient, a curve for the determination of which is given in the paper. The error may amount to 2 per cent. in the case of anthracite and some lignites.

Pyrometry.—The collected writings of H. A. Seger, prepared from the records of the Royal Porcelain Factory at Berlin and translated into English by the members of the American Ceramic Society, are now being published, and the first volume has appeared. They are of special interest as containing the voluminous work done by Seger on the refractory nature of clays and the use of his cones for determining temperatures.

A new apparatus for the determination of the melting-point of metals is described by H. Thiele. § The chief advantages are said to consist in its capacity to register high temperature, and in the simplicity and durability of its construction.

II.—*COAL.*

Origin of Coal.—J. F. Hoffmann ‖ discusses the formation of coal at considerable length. He finds that the heat generated by the decomposition of starch into carbon and water would be sufficient to raise the temperature of the mass to 670° or 800° C, or still higher if carbonic anhydride, marsh gas, and carbon were formed. The heat generated in this way might aid in producing the change of vegetable matter into coal, and much reliance is placed upon this effect of spontaneous heating as the agent for the change.

* *Sitzungs-Bericht des Vereins zur Beförderung des Gewerbfleisses*, 1902, p. 143.

† *Bergbau*, June 1902, pp. 4-6.

‡ *Comptes Rendus de l'Académie des Sciences*, September 22, 1902.

§ *Zeitschrift für angewandte Chemie*, vol. xxxi. pp. 780-781.

‖ *Ibid.*, vol. lxxiv. pp. 416, 821-831.

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small extent, except on the outcrop. The seam is being worked on certain freehold property in the south-west of the coalfield. Over this property the top series is wanting, the lower series only being intact, the seams of which crop out to the surface. Some exploratory work has been done, and this is described, a general account of the run of the seams being given. Owing to local conditions, and especially to the faults and water, the system of working adopted is a modification of bord-and-pillar. A modification of the longwall system has also been tried with some success.

Coal in Somerset.—F. A. Steart * discusses the overthrusts and other disturbances in the Braysdown colliery, and the bearing of these phenomena upon the effects of overthrust faults in the Somerset coalfield in general.

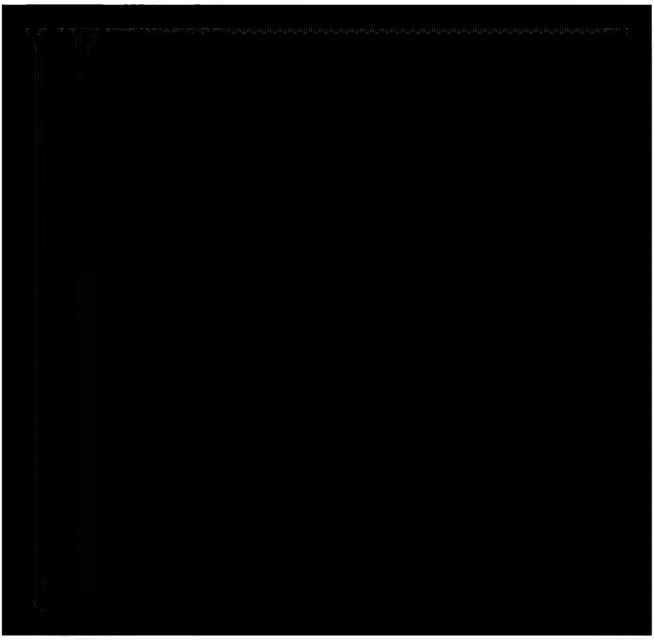
Re-survey of the South Wales Coal Measures.—For some years past the Geological Survey have been engaged on a re-examination and re-mapping of the areas of carboniferous rocks in Great Britain. The work has recently necessitated the examination of the Lower Palæozoic rocks. The Ordovician and Silurian rocks, which are immediately concerned, have been examined, but no natural undisturbed junction has been met with. Evidence of faulting, probably accompanied by overthrusting, has been found all along the line, and the dominant movements have been connected up with the disturbances of Cribarth and the Vale of Neath. Inliers of Silurian rocks, hitherto unsuspected, have been found in Gower, thus proving a great but probably local diminution in the thickness of the Old Red Sandstone. No definite separation of Upper and Lower Old Red Sandstone has yet been found possible. The sequence of red beds appears to be conformable throughout; but, on the other hand, there are signs of an unconformity between the Old Red Sandstone and the Silurian rocks.

The deep trough of coal measures extending from Swansea to Llanelly was further examined last year and found to contain some of the highest measures of the coalfield. A full account of the investigations last year is published in the "Summary of Progress of the Geological Survey for 1901."

Coal in Scotland.—R. Kirkby † gives a detailed account of the

* *Quarterly Journal of the Geological Society*, vol. lviii. pp. 609–619.

† *Transactions of the Institution of Mining Engineers*, vol. xxiii. pp. 291–310.



is described by W. Setz.* Suggestions for the further exploration of the anthracite beds known to exist there are discussed.

E. Prziwoznik † gives twenty-nine complete analyses of brown coals from various Austrian localities.

H. Haberfelner ‡ observes that the average width of the brown-coal seam in the Tertiary Fohnsdorf basin is slightly less than 10 feet. The seam has, however, a number of small shale partings which may reach a maximum of some 10 inches in thickness.

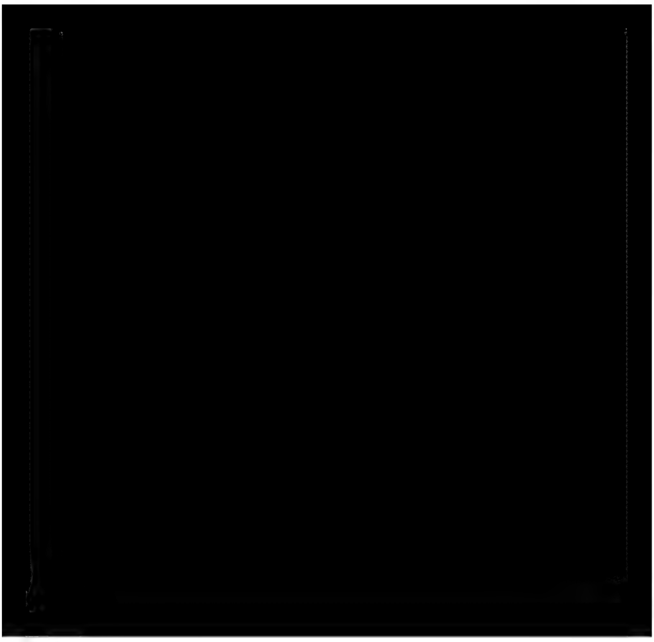
Coal in Belgium.—G. Simoens § discusses the probable extension of the coal measures in the north of Belgium.

The search for coal at Westerloo in Belgium has met with success. At 600 yards depth a seam of coal has been encountered. ‖

Recent investigations have proved that a coal basin extends in a west-north-westerly direction from the Meuse border of the Limburg province to the north of the town of Antwerp, the distance between the extreme borings—at Lanklaer and Westerloo—being about forty miles, with a mean width of five and a half miles. It is believed that the new field is an extension of the Midland coalfield of Great Britain. So far thirty-seven borings have been made, with four in the province of Antwerp, and great variation in thickness and the proportion of volatile matter has been found. Some bores have shown about 16 feet of coal in about 320 feet of coal measures, whilst neighbouring bores have shown very inferior results. The percentage of volatile matter has been found to vary as much as from 18 to 35 per cent. within a distance of two and a half miles, and as a rule the volatile constituents appear to decrease as the coal increases in depth. In some cases shafts will have to be sunk over 650 yards. ¶

Coal in Bulgaria.—In a paper on the mining industry of Bulgaria, Wallmer ** gives particulars of the occurrence of coal in that country. The largest undertaking is the Pernik brown-coal mine, which affords employment to a thousand workmen. The seam is three yards in thickness, and is of Eocene age.

* *Montan Zeitung*, vol. ix. pp. 321-322.
† *Berg- und Hüttenmännisches Jahrbuch des k. k. Bergakademien*, vol. l. pp. 437-439.
‡ *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. l. p. 231.
§ *Bulletin de la Société Belge de Géologie*, vol. xvi. pp. 182-189.
‖ *Echo des Mines*, vol. xxix. p. 838.
¶ *Colliery Guardian*, vol. lxxxiv. p. 518.
** *Montan Zeitung*, vol. ix. p. 393.



competition 85 companies have formed themselves into one syndicate. They have a joint output of 57 million tons, out of the total output in the Rhenish-Westphalia district of 75 million tons.

A. Middelschulte * gives a description of the formations overlying the coal deposits of the Ruhr basin. Two water-bearing zones exist in these, which are separated by the Emscher marl. The lower one is distinct from the upper on account of the saltness of its water.

Jacob † describes the eastern faults in the Aachen coalfield with special reference to their geological age.

An official description of the minerals of economic importance met with in the Düren district has been published by the Mining Department of Bonn. Coal seams are abundant, no less than forty-six being known. Brown coal has been found by boring to be widely distributed.

R. Dorstewitz ‡ gives a geological description of the brown coal basin of Helmstedt.

K. Dalmer § indicates places in Saxony where it might be advisable to bore for coal.

R. Michael ‖ describes the stratigraphy of the Upper Silesian coalfield.

H. Stille ¶ describes the occurrence of coal in the Middle Keuper at the Teutoburg Forest near Neuenherse.

The exhibits illustrating the occurrence of coal in Germany shown at the Düsseldorf Exhibition are described by Mentzel.**

Coal in Holland.—The coal basin of Limburg in Holland is described and illustrated.††

H. Zondervan ‡‡ describes the occurrence of coal in Dutch Limburg.

Coal in Hungary.—The brown coal deposits at Verceserova in Hungary are shortly described.§§

* *Zeitschrift für das Berg-, Hütten- und Salinenwesen im preussischen Staate*, vol. l. pp. 320-345.

† *Zeitschrift für praktische Geologie*, vol. x. pp. 321-337.

‡ *Braunkohle*, 1902, pp. 195-200, 208-212.

§ *Zeitschrift für praktische Geologie*, vol. x. pp. 223-225.

‖ *Jahrbuch der kgl. Preussischen geologischen Landesanstalt*, vol. xxii. pp. 317-340.

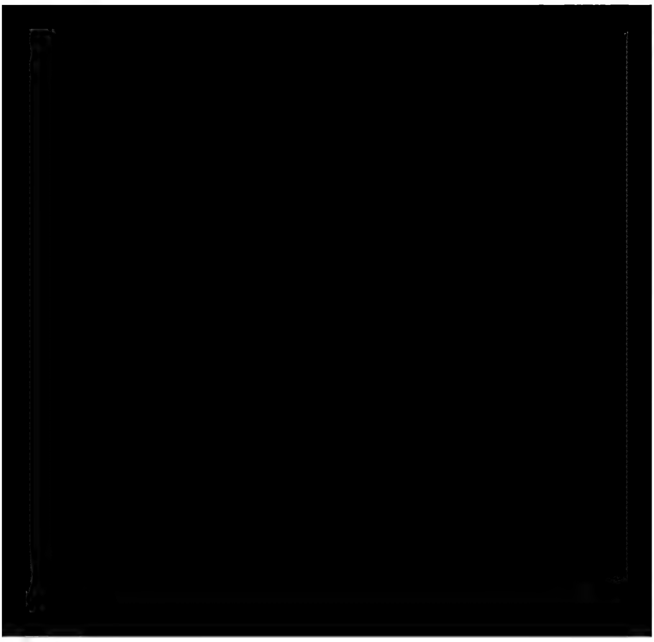
¶ *Ibid.*, vol. xxi. pp. 58-63.

** *Glückauf*, vol. xxxviii. pp. 500-512.

†† *Berg- und Hüttenmännische Zeitung*, vol. lxi. pp. 363-366.

‡‡ *Petermann's Mittheilungen*, vol. xlvii. pp. 187-190.

§§ *Berg- und Hüttenmännische Zeitung*, vol. lxi. pp. 277-278.



great thickness. Sandstones and shales lie between them as partings of greater or lesser thickness. The seams lie at considerable distances apart, and it is only seldom that several of them can be worked from the same shaft. At present some of the shafts attain a depth exceeding 690 feet, and while up to now firedamp has been altogether absent, some trouble is now being experienced.

The coal of the Donetz basin not only exists in immense quantities, but it is very variable in quality. All kinds of coals are met with, from long-flame non-caking steam coals to anthracites. The first-named occur in the north-eastern portion of the field near Lissitschanka, and long-flame bituminous coals near the Marjenska station and Varvaropolje. The seams in the south and south-west are partly these bituminous coals and partly true coking coal, while those in the eastern part of the district are anthracitic coals or anthracites. The Donetz coals are used mostly in the local metallurgical works, on the South Russian railways, in part on the steamers of the Black Sea, and in the sugar and other factories.

The second most important coalfield of Russia, as far as output is concerned, is that of Poland or the Dombrova basin. This is a continuation of the Upper Silesian field. The Carboniferous deposits are sandstones and shales, and can be divided into a productive portion containing coal and one that does not. The coal seams belong to three groups, the central one of which is represented by the Reden seam. This has a thickness of as much as from 34·5 feet to 52·5 feet. Above this lie twelve seams and below it nine. The twelve upper seams have a total thickness of between 62 and 63 feet, and the nine lower seams a total thickness of 48 feet. The coal is not suitable for gas-making or coke manufacture. Until quite recently the three groups of seams were mined in a faulty manner, so much coal being lost and fires being so frequent that the Government took the matter in hand, and regulations were introduced, according to which these seams have to be mined. Mining operations in this district are accompanied by the danger of flooding from the overlying Bunte sandstone beds, which hold much water. Coal mining began at the commencement of the past century, but has only attained importance since the construction of the Russian railway system. At present there are at Dombrova and its vicinity twenty collieries and a brown coal group, which together have an annual output of about 3,700,000 tons. The Polish coal is chiefly purchased by the works in the Losnovitz manufacturing district, and those of Lods and Warsaw, together with the

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and of brown coal are also mentioned, including those of Saghalien, which, in time, are likely to prove of importance.

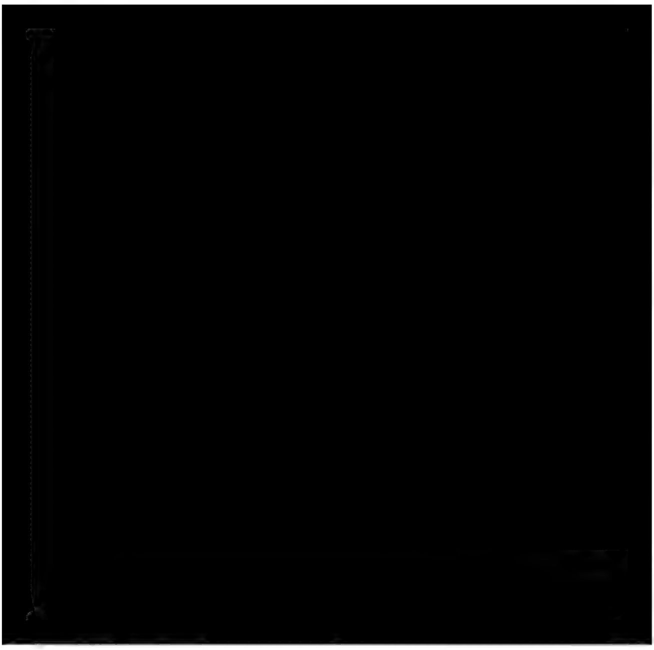
Peat is met with in forty-five provinces of European Russia, but is relatively little worked, or only by primitive means. Much is also found in other parts of the Russian Empire. Bituminous shale, which is suitable both for distillation purposes and as fuel, is also of frequent occurrence.

At Sudschenka, in the government of Tomsk, 10 miles from the Central Siberian railway, B. Korwin-Sakovitsch * has discovered a coalfield containing sixteen seams of a foot to 8 yards in thickness. They dip at an angle of 75° and are embedded in clay slate. Analysis of the coal gave 13 per cent. of volatile constituents, 78 per cent. of coke, 0·8 per cent. of sulphur, 6·7 per cent. of ash, and 1·5 per cent. of moisture.

It is pointed out † that while the Ural is rich in mineral wealth, and especially in iron ores, its deposits of mineral fuel are very scanty. At present, therefore, its blast-furnaces are chiefly dependent on charcoal, and the price of this varies from 19s. to 20s. per ton at the works, according to the distance carried and the nature of the transport. The charcoal is, therefore, solely employed for blast-furnace use, while for boiler firing peat is sometimes used, in part at least, and wood in the producers. Some of the works also utilise the waste gases from the furnace in the stoves and boilers. At the Kischtim works the whole of the plant is being rebuilt on modern lines, and a large central power station erected which will utilise the gas from two large blast-furnaces. As mentioned above, some mineral fuel is found in the district, both anthracite, coal, and brown coal being met with. The coal occurs near Lunjevka, to the south-west of Bogolovski. A few coke ovens are in operation at this point, but the coke is too weak and porous for satisfactory blast-furnace use. Still, though mineral fuel is found, the deposits are unimportant, and the Ural district must look elsewhere for coal and coke. The proposal to bring these from the Donetz basin of South Russia would necessitate a new line of railway, but great hopes are held with regard to the possibility of utilising the large coal deposits which have become available owing to the construction of the great Siberian railway. Before all others the Sudschenka coalfield receives most consideration. The coal of this field is better for metallurgical purposes than those of Pavlodar, Jrkutsk, or Krassnojarsk.

* *Geologisches Centralblatt*, vol. ii. p. 582.

† *Berichte über Handel und Industrie*, March 8, 1902; *Stahl und Eisen*, vol. xxii. pp. 467–468.



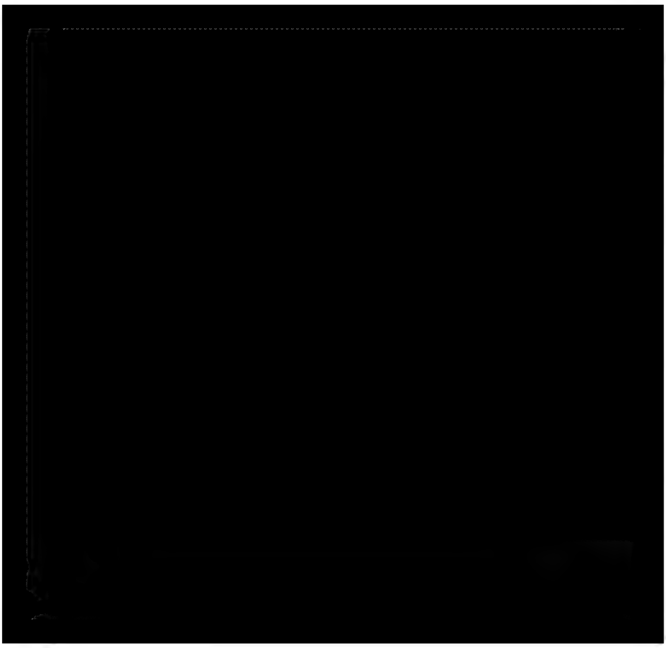
An article on coal in Spain has been published * in which the Belmez coalfield is described in detail.

The lignites of Aragon are described by A. Gaston. †

Coal in Bear Island.—J. G. Andersson, ‡ who took part in two Swedish expeditions, describes the geology of Bear Island. Silurian, Devonian, Carboniferous, Triassic, and recent formations are represented. The coal deposits are of importance. The total amount available is estimated at 100,000,000 tons. The coal contains, however, 5·87 to 47·10 per cent. of ash.

Coal in India.—The Director of the Indian Geological Survey has issued his report for the year ending March 31, 1902. In the portion devoted to coal it is stated that in the Bikanir State an attempt was to have been made to ascertain whether any coal horizons, other than those already known, were in existence; but the failure to start work of the contractors who undertook the boring has prevented any decisive work from being carried out. The investigations made in the Jherria coalfield are described at some length. In this field are three series of rocks—the Raniganj Upper Damudas, the ironstone shales, and the Barakar Lower Damudas. The first contains workable coal, but at a distance from any existing line. The second does not contain coal, but divides the first and third series. The third is divided into two systems—the Talchar beds, which are unimportant, and the Damudas, which comprise no less than eighteen seams, varying from 5 to 30 feet in thickness. Below the third series are the Talchar beds, which are unproductive in coal. The Lower Damuda series (Raniganj) have no less than eighteen seams of coal, varying from 5 to 45 feet in thickness. Of the seams only about half have as yet been worked, and to the west of the Khoda river a considerable area still awaits development. Though this part of the field has been hitherto deemed of little value, the experts consider that this opinion is not justified. The information to hand on the Lashio coalfield, in Burma, is as yet incomplete; coal exists, and in workable seams of good thickness, but both their extent and the quality of the coal have yet to be determined. The working will present a certain amount of difficulty, as the coal is not surrounded by rock, but is contained in beds of soft sand or sandy clay. The coal of the Nambar forest in Assam is said to be dirty and of inferior

* *El Minero Mexicano*, June 5, 1902.
† *Boletin Minero*, vol. v. pp. 1-2, 45-47, 107.
‡ *Geologiska Föreningens Förhandlingar*, vol. xxiii. pp. 219-230.



Bulawayo. Prospecting operations have proved the existence of three seams of coal with thicknesses ranging from 4 feet to 14 feet. The upper seam, which is 7 feet to 9 feet thick, runs along the foot of the hill, and has been proved for a considerable distance both by shafts and adits. The quality of the coal is equal to the average for South Africa. It is anticipated that this coalfield will supply the gold-mining districts of Salisbury, Gwelo, Selukwe, and Sebakwe. This discovery of good coal has come at a most opportune moment, for, notwithstanding the small number of producing mines at work in these districts, the supplies of timber are already beginning to become scarce.*

Coal in the United States.—A. C. Lane † discusses the origin, occurrence, analyses and tests, erosion disturbances and development of coal in Michigan. It is allotted to the "seral conglomerate" or millstone grit portion of the Pottsville formation, low down in the Carboniferous series. There are seven distinct coal horizons, of which three are mined. These three are termed the Saginaw, and Lower and Upper Verne. The following are characteristic analyses :—

	Saginaw.	Lower Verne.	Upper Verne.
Moisture	10·67	8·71	9·57
Volatile constituents	33·59	38·45	40·93
Ash	1·94	11·68	4·35
Fixed carbon	53·80	41·16	46·13
Sulphur	1·01	2·72	0·98

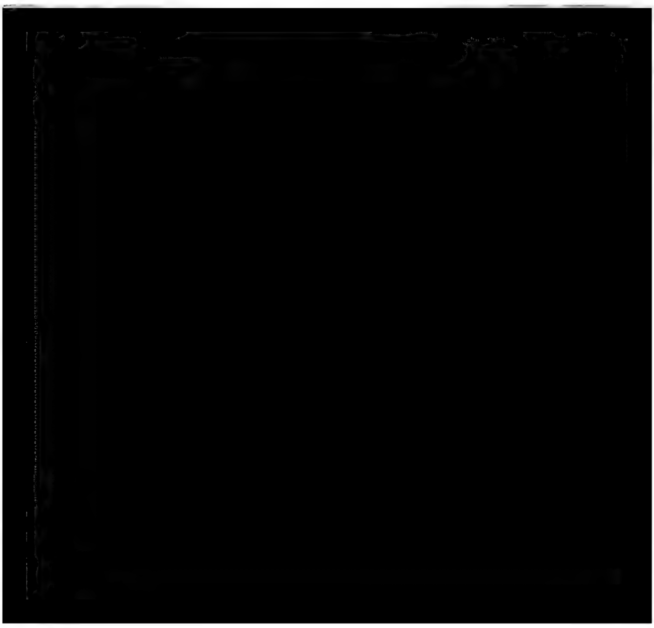
J. A. Taff and G. I. Adams ‡ describe the geology of the Eastern Choctaw coalfield, Indian Territory.

J. A. Taff § has published a preliminary report on the Camden coalfield of South-Western Arkansas.

Coal in Asia Minor.—W. Möllmann ‖ gives an account of the occurrence of coal in Asia Minor.

Coal in China.—The Kaiping coal mines and coalfield, Chihle province, North China, are described by H. C. Hoover.¶ The number

* *Mining Journal*, vol. lxxii. p. 1113.
† *Geological Survey of Michigan*, vol. viii. Part II.
‡ *Twenty-first Annual Report of the U.S. Geological Survey*, Part II. pp. 257-311.
§ *Ibid.*, pp. 313-329.
‖ *Glückauf*, vol. xxxviii. pp. 865-867.
¶ Paper read before the Institution of Mining and Metallurgy, June 19, 1902.



Utilisation of Peat.—Illustrations are given of the plant for the utilisation of peat. The material is dug and taken by an inclined conveyer to a kind of disintegrating and pug mill, which makes it into blocks. These are loaded into trucks and run through drying chambers, where the moisture is reduced to 8 or 10 per cent. The blocks can then be used as fuel; but in O. Daube's process they are run through coking ovens of similar construction to the drying ovens. By-products are recovered, and the waste gas used for heating. By another process the dried blocks are used in a gas-producer. Sections of the ovens and of the producers are given.*

The Swedish Department of Agriculture has published a report by A. Larson and G. Wallgren † on the use of peat as fuel in Europe. The report covers 363 pages, and contains 225 original illustrations. The countries in which the peat industry was studied include Sweden, Denmark, Germany, Holland, Belgium, France, Russia, and Finland. The present annual import of coal into Sweden is equivalent to 5,700,000 tons of peat, and that amount could easily be raised after about ten years' development.

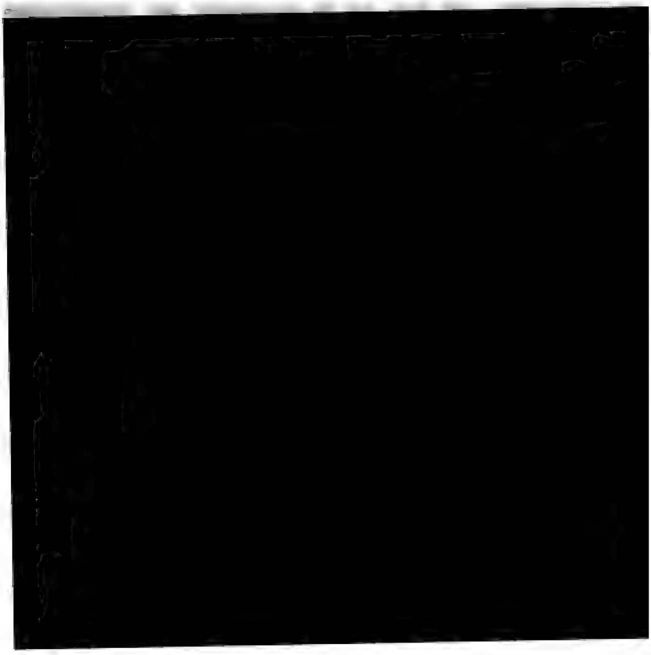
J. G. Thaulow ‡ describes the four machines used in Sweden for manufacturing peat fuel.

Platinum in Coal.—In a report dealing with the geological relations of platinum, J. F. Kemp § directs attention to a most extraordinary case that has been recorded of the presence of platinum in the ash of certain Australian coals, along with vanadium. The coal as analysed by Thirkell & Co., of London, yielded: Carbon, 65·2; hydrogen, 4·6; oxygen, 21·8; nitrogen, 1·9; sulphur, 3·8; moisture, 0·7; ash, 1·7—total, 99·7. The ash yielded 25·1 per cent. of vanadium and 3·6 per cent. of platinum metals. This makes the coal the richest crude platinum ore yet assayed.

III.—*CHARCOAL.*

Charcoal Manufacture in the Lake District.—The conditions which regulate charcoal burning in the Lake District of England are

* *Engineering News*, vol. xlvii. pp. 476-477.
† *Om bränntorfindustrien i Europa*, Stockholm, 1902.
‡ *Teknisk Ugeblad*, Christiania, 1901, p. 491.
§ *Bulletin of the United States Geological Survey*, No. 193, p. 35.



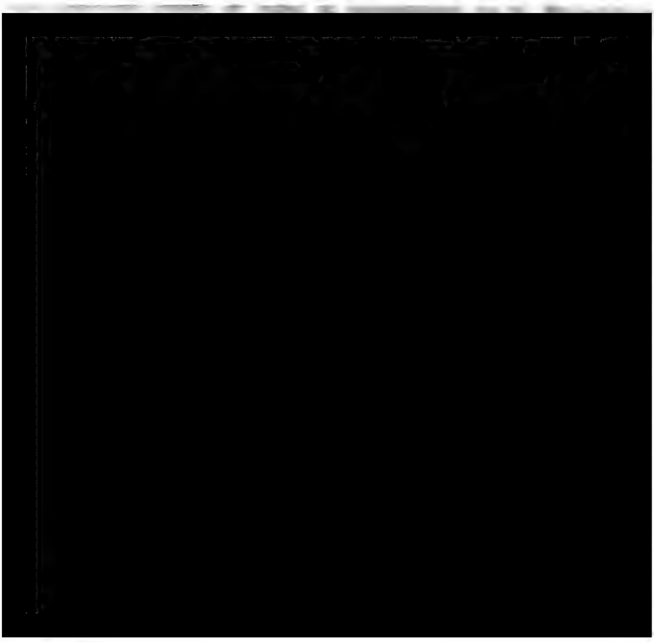
trolleys and run through a drying tunnel heated by waste gases from the retorts at 90° to 100° C. The dried briquettes are charged into retorts consisting of vertical iron cylinders about 80 inches high and 40 inches in diameter, where they are heated by electric resistances. The gas is passed through scrubbers to remove tar, &c., and then is used for heating the drying tunnels, of which there are two. The charcoal is cooled to 130° in the retorts, discharged, and sold.

The manufacture of peat charcoal by electricity at the Stangfjord works is described by H. Landmark.*

F. Toldt † discusses Schnablegger's process for making coke from sawdust, peat, lignite, and brown coal. The author considers that not only is the principle of the process accurate, but that it forms the only practicable way of attaining the desired end. The process has been patented, and full details are not published, but the author states that good hard coke can be made by the Schnablegger process, and gives in proof of his statements photographs of three specimens of coke from sawdust, two from peat, and three from brown coal. The sawdust coke has a structure resembling shavings, but it is black and lustrous like coke. The sawdust was probably placed too loosely in the oven, yet at the same time there is evidence that the oven contents were fused. The peat charge had also been completely melted in the oven, as, too, had that of brown coal. In both cases the coke produced resembled in structure, colour, and appearance good ordinary coke. The author is acquainted with the nature of the process, but his knowledge is of a private character, and all he feels at liberty to state is that the material to be coked is first altered in chemical composition, then mixed with certain additions and subjected to a fusion process. The best material for this process would be that in the finest state of division, coal dust forming an ideal coking substance. The ash contents play an important part; the higher the ash of the raw material, the dearer in this case being the coke produced. The author gives some details as to the cost of coking brown coal by this Schnablegger method. The various cokes made, he adds, will all be of use for metallurgical purposes, and would replace the coke in blast-furnace work if the size of the lumps increases with the use of wider coking ovens than those that have been experimented with. The process is stated to be very simple in character.

* *Teknisk Ugeblad*, 1901, pp. 549–555.

† *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. l. pp. 195–197, with one illustration.



G. R. Bale * asserts that the coke should be hard, and in fact the best obtainable. It should not contain more than 0·75 per cent. of sulphur.

V.—*LIQUID FUEL.*

Origin of Petroleum.—J. Ohly † argues in favour of the mineral origin of petroleum from the reaction between water and carbides of iron and other metals. A number of gaseous hydrocarbons are formed in this way which may be condensed through polymerisation into the liquid hydrocarbons.

In some notes on diatom earth in Arizona, W. P. Blake ‡ refers to the fact that some of these deposits yielded bitumen on distillation, and that specimens of two species of living diatoms contained oil.

G. Kraemer § discusses the genesis of petroleum with special reference to its relations to the plant world.

C. E. Waters ‖ discusses Kraemer and Spilker's theory of the formation of petroleum from diatoms, and Engler's comments thereon.

An account has been published of the researches of P. Sabatier and J. B. Senderens on the synthesis of petroleum.¶ Starting with acetylene and hydrogen, they have, with the aid of metallic nickel, succeeded in obtaining, according to the manner in which the reaction is conducted, liquids similar to American, Caucasian, or Galician petroleum.

J. Muck,** discussing the condition of the petroleum industry in the nineteenth century, enumerates the principal localities at which petroleum occurs, and gives statistics of the world's production from 1860 to 1890.

The literature dealing with the petroleum industry in the year 1901 is systematically reviewed by R. Kissling.††

* *Modern Iron Foundry Practice*, Manchester, 1902.

† *Mines and Minerals*, vol. xxii. pp. 532–533.

‡ *Transactions of the American Institute of Mining Engineers*, February and May, 1902.

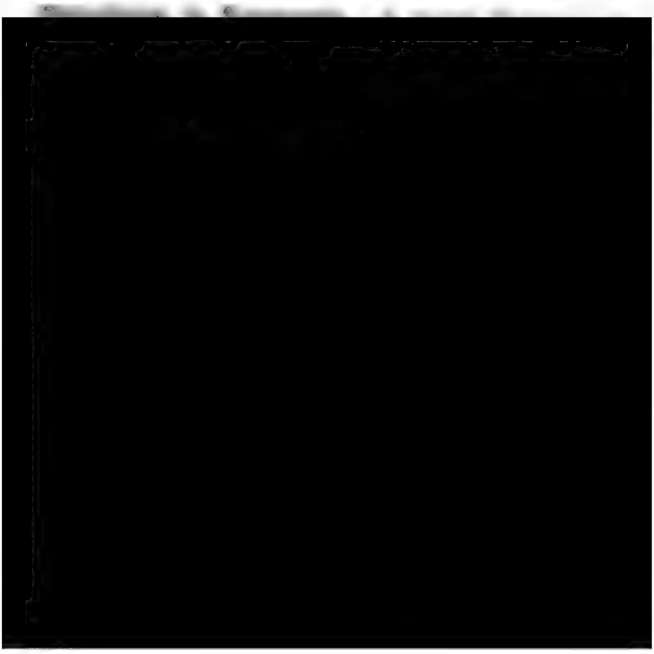
§ *Sitzungs-Bericht des Vereins zur Beförderung des Gewerbfleisses*, 1902, p. 93.

‖ *American Chemical Journal*; *Petroleum Review*, vol. vii. p. 201.

¶ *Revue Scientifique*, vol. xvii. p. 726.

** *Berg- und Hüttenmännisches Jahrbuch der k. k. Bergakademien*, vol. l. pp. 117–148.

†† *Chemiker Zeitung*, vol. xxvi. pp. 490–492.



and Neogenic deposits. The Cretaceous series include those of Prahova and Dambovitza. Moldavia and Mentenia contain the Paleogenic deposits, and these are considered in some detail, as are also the Neogenic deposits in the same districts and in Oltenia.

G. Schultz * gives the result of an investigation of Roumanian refined oils, giving the flash and boiling points, photometric and other tests.

P. Poni † has published an elaborate memoir on the chemical composition of Roumanian petroleums.

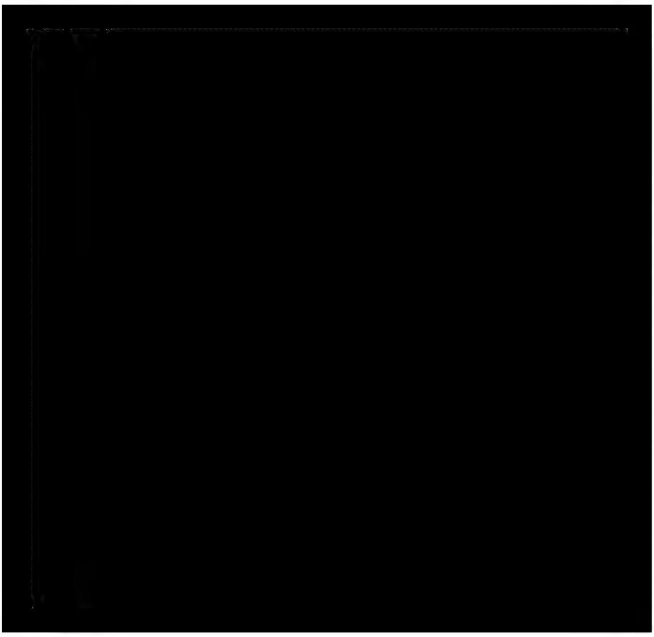
The Roumanian petroleum industry is dealt with by L. Liddell, ‡ British Vice-Consul.

Petroleum in Russia.—According to Lamansky,§ the petroleum deposits of Russia occur (1) in the Archangelsk province, on the Uchter river; (2) in the Samara province, on the Soku and Volga rivers; (3) in the Keletz province; (4) in the Ural district, in the Kalmikov and Gurjev districts; (5) in the Turgai division, in the Iletz district, on the Dschuss river, and in the Mugodjars; and finally (6) in Nova Zembla. Most of these are still unworked, or but imperfectly known. The chief deposits are on the northern and southern slopes of the Caucasus, and especially in the Apscheron Peninsula. The various deposits are dealt with, and statements are made as to the occurrence of asphalt, ozokerite, and kir, the latter being earth impregnated with naphtha. In European Russia, asphalt, or more correctly asphaltic limestone, occurs in vast deposits along the banks of the Volga, of the Sisrans, and of the Irisma rivers, the annual output being some 170,000 tons. Asphalt also occurs in the Kasan and Samara provinces, while bitumen is met with in the districts of the Urals and Tereks, and in the provinces of Kutais and Tiflis, and ozokerite in many parts of the Caucasus and on some of the islands of the Caspian Sea. It also occurs in Transcaucasia, Ferghane, Khiva, and on the banks of the Baikal.

J. Muck ‖ describes a new petroleum field in the Caucasus. It is situated near Zemo-Chodascheni, in the government of Tiflis.

M. L. Szajnocha ¶ discusses the origin of the petroleum at Wocjcza

* *Chemiker Zeitung*, vol. xxvi. pp. 451–452; *Petroleum Review*, vol. vi. pp. 593–598.
† *Moniteur des Intérêts Pétrolifères Roumains*, vol. iii. pp. 531–535, 573–576, 616–619.
‡ *Mining Journal*, vol. lxxii. p. 1146.
§ *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. l. pp. 419–421.
‖ *Chemiker und Techniker Zeitung*, vol. xx. No. 1.
¶ *Anz. der Akademie der Wissensch. Krakau*, 1902, pp. 219–220.



The principal productive field is in South-Eastern Kansas and the northern part of Indian territory. The coal measure rocks of Iowa have hitherto not proved productive. The northern Texas area has not yet been largely investigated. In the upper Cretaceous area there is a productive oil-field at Corsicana, Texas; and within the Tertiary area occur the oil-fields of Nacogdoches and Sour Lake, and the remarkable discoveries of oil at Beaumont, Texas.

R. T. Hill * gives a comprehensive account of the geography, geology, and other features of the Beaumont oil-field, and notes on the other oil districts in the Texas.

W. W. Reed † gives two evaporative tests of Beaumont oil as 13·48 and 14·71 lbs. of water at 212° F. per lb. of oil, and finds that the sulphur in it had no injurious effects on boilers after ten months' use. Some tests of different burners are also given.

Petroleum in Cuba.—T. W. Vaughan ‡ gives a summary of the investigations of himself and others on the occurrence of bitumen and oil in Cuba.

Asphalt.—A full report on the asphalt and bituminous rock deposits has been made by G. H. Eldridge. § The situation, geology, statistics, and other details of these materials are given for each State in the United States, and numerous photographs, sections, and maps are appended.

A. W. Dow ‖ gives a short history of the asphalt industry in America, chiefly in reference to the paving industry; but various references to the different deposits are included, and accompanying the article are a number of statistics compiled from various sources.

J. Kovacs ¶ describes the occurrence and uses of asphalt, and gives a table of the localities producing this material and analyses of the product.

Boring for Petroleum.—Some particulars are given of deep bore-

* *Journal of the Franklin Institute*, vol. cliv. pp. 143-156; *Transactions of the American Institute of Mining Engineers*, February and May, 1902.

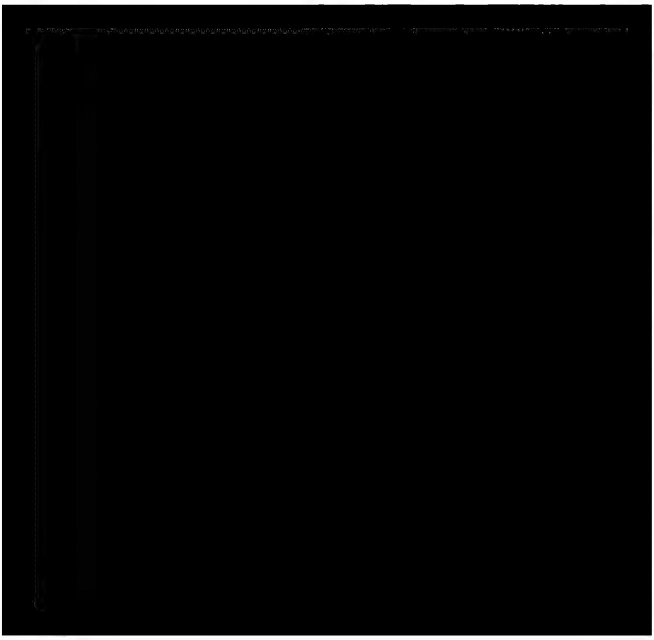
† Paper read before the South-Western Gas, Electric and Street Railway Association: *Iron Age*, May 22, 1902, pp. 20-22.

‡ *Engineering and Mining Journal*, vol. lxxiii. pp. 344-347.

§ "Asphalt and Bituminous Rocks of the United States," *U.S. Geological Survey*, pp. 211-464.

‖ *The Mineral Industry*, vol. x. pp. 45-57.

¶ *Petroleum Review*, vol. vi. p. 698; vol. vii. pp. 40-42, 66-67, 118-119.

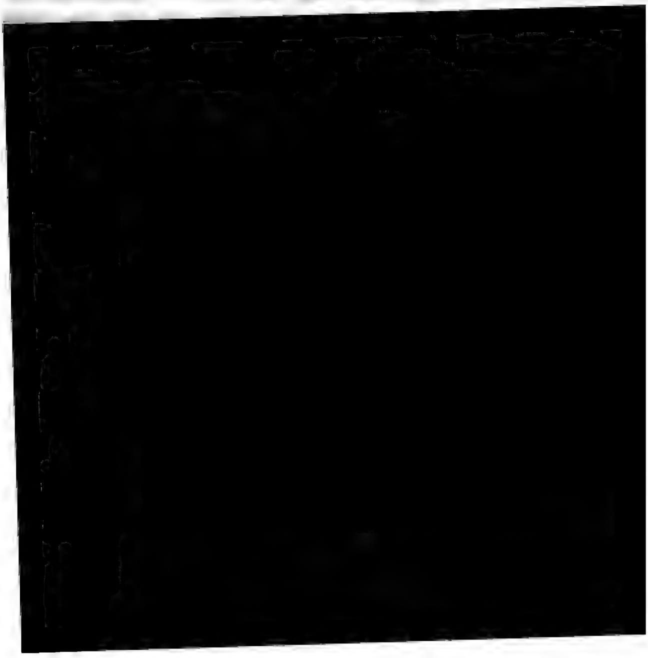


England, Limited, gives the history of the discovery of gas in the district, and some views of the wells being sunk.

Natural Gas in the United States.—A good account of the present condition of the natural gas industry in the United States is given by W. H. Hammon.* The present supply is obtained from more than 10,000 wells, varying in depth from a few hundred to 3000 feet, and the rock pressure is sometimes as high as 1000 lbs. per square inch. The gas was first piped from the wells about 1881, and now the pipe lines are laid up to distances of more than 150 miles, and one line of 200 miles is under construction. The pipes used vary from 2 inches to 3 feet in diameter. Pipe below 10 inches in diameter is made with screw couplings, and up to 2 feet with flange joints. Above that size cast iron or riveted steel pipe is used. In the aggregate there is probably 25,000 miles of piping in use. Generally the gas is forced through the pipes by its natural pressure, but large recourse is had to pumping when the wells are becoming exhausted or when the pipes are very long. With gas engines a consumption of 1 cubic foot of gas will compress 30 cubic feet to a pressure of 270 lbs. per square inch. An illustration is given of a large gas engine compressor plant, with four combustion cylinders 25 by 48 inches, two first stage compressor cylinders 31 by 24 inches, and two second stage compressor cylinders 15½ by 24 inches. Sixteen cubic feet of gas will give one horse-power hour. Four methods are in vogue for measuring gas viz., meters, Pitot tubes, computation from the initial and discharge pressures and the length and size of the pipes, and (fourth) by calculating the output of the hole from its volume and the pressure attained after closing it for one minute. The formulæ used in these four methods are given. The sources of the gas are then discussed, and it is pointed out that the most prolific fields are those along the western slope of the Appalachian mountain system from the Canadian border to Tennessee, and those throughout the great anticlinal from Kentucky to beyond Lake Erie. The latter is known as the Cincinnati Arch, with its centre near Cincinnati. These two fields produce 95 per cent. of the total production in the United States. A brief review of the various deposits and their present conditions is then given, followed by short notes on the origin of the gas, the cause of the pressure, and the chemistry and uses of the gas.

Natural Gas in the Caspian Sea.—At a meeting of the Russian

* *The Mineral Industry*, vol. x. pp. 464–483.



samples of Russian, Pennsylvania, Borneo, and Texas oil used for the manufacture of gas.

VIII.—*COAL-MINING.*

Deep Boring.—Several methods of deep boring have recently been devised, in which the tool only, and not the rods, receives the percussive movement. In these appliances, of which a description has recently been given,* the action is dependent on the alternate flow and interruption of the water column in the hollow rods to produce a water-hammer action somewhat analogous to that utilised for raising water by the water-ram. Different types of these apparatus have been devised by Howarth, Pruszkowski, and Wolski.

An illustration is given † of the electrically driven Davis-Calyx drill at work in the Calder pit of the Mirfield Colliery Company, Yorkshire. The drill is fixed at a depth of 600 feet from the surface, and the bore has pierced a further depth of 700 feet, and is proceeding. The cores from the boring are also shown.

L. V. Emanuel ‡ describes the method of core-drilling with the Davis-Calyx drill, and gives a number of illustrations to show the more recent forms of apparatus, especially those for driving the rods. The use of chilled shot instead of teeth with a crown tool is also described as being adapted for harder rocks.

Robert Pitaval § gives particulars of the boreholes put down in the Pas de Calais south of the fault bounding the coalfield. The aggregate depth of these boreholes is 12,000 yards. Five of the boreholes have already encountered the coal measures. The deepest boreholes are those of Bois-Bernard 1160 yards, Marest 950 yards, La Comté 920 yards, Aix-Noulette 850 yards, and Ourton 820 yards. The four first were put down with the diamond drill. Experience tends to show that in the conditions that obtain in the district the best plan is to adopt percussive boring for the first 700 yards and then to use the diamond drill.

A paper containing a number of notes on deep-boring has been published by T. Tecklenburg.||

* *Iron and Coal Trades Review*, vol. lxv. pp. 405–406.
† *Ibid.*, p. 153.
‡ *School of Mines Quarterly*, vol. xxiii. pp. 219–233.
§ *Echo des Mines*, vol. xxix. pp. 786–788.
|| *Glückauf*, vol. xxxviii. pp. 1002–1005.

deep and the gear raised to bank in 2½ hours. The average progress of sinking was 7½ yards per week.*

Some particulars have been given to show the rapidity attained in sinking shafts in South Africa, Australia, and England. The most rapid appears to be 167 feet in an 11-foot shaft, but of course the rate depends entirely on many circumstances, such as hardness of rock, amount of water, &c. Nevertheless the figures may be of interest.†

L. Bouchut ‡ describes the method of shaft sinking employed at the Pinel colliery.

Stengl § gives an account of the new plant at the Ronchamp coal mines. The depth of the winding shaft is 3300 feet.

W. R. Crane ‖ describes the sinking of a shaft to work two seams at depths of 799 and 1126 feet at Atchison in Kansas. The shaft is rectangular, 15½ by 7½ feet in the clear. To a depth of 250 feet the work has been done mainly in limestone, sandstone, and shale. Rock drills on transverse columns are used for drilling the blast-holes, which are arranged to blow out the centre and then the sides. Timber cribbings are used.

Hundhausen ¶ gives a short general description of the freezing process as applied to mining. T. Koster ** describes the application of the freezing method in sinking shafts near Eygelshoven, Limburg. The cost is £160 to £200 per yard depth.

The methods of shaft sinking illustrated at the Düsseldorf Exhibition are described by G. Herbst.††

Winding Appliances.—C. Liddell ‡‡ describes the arrangements at the upcast shaft at Woodhorn colliery so that winding may be done with the minimum loss of air. The top of the shaft and bottom of the frame are enclosed in a brick building 52 by 17½ feet, and 25 feet in height, with air-lock doors.

H. C. Behr §§ discusses at very considerable length the problems

* *Engineering*, vol. lxxiv. pp. 40, 43-44; *Engineer*, vol. xciv. p. 30.
† *Colliery Guardian*, vol. lxxxiv. p. 400.
‡ *Comptes Rendus Mensuels de la Société de l'Industrie Minérale*, 1902, pp. 109-115.
§ *Organ des "Verein der Bohrtechniker,"* September 1, 1902.
‖ *Engineering and Mining Journal*, vol. lxxiv. pp. 108-109.
¶ *Montan Zeitung*, vol. ix. pp. 324-326.
** *De Ingenieur*, 1901, p. 457.
†† *Glückauf*, vol. xxxviii. pp. 521-534, with five plates.
‡‡ *Transactions of the Institution of Mining Engineers*, vol. xxiii. pp. 195-197.
§§ Paper read before the Institution of Mining and Metallurgy, London, May 15, 1902.

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useful load of 4·15 tons in one lift from a depth of 1640 feet at a maximum speed of 65⅝ feet per second. Continuous current will be supplied at 500 volts from generators in conjunction with regulator batteries to drive the two 1400 horse-power motors. The driving drum is placed between the motors, which are keyed on its shaft, and either motor may work separately, or they may be worked in series or in parallel. The current controller is worked by a compressed air engine, and compressed air also works the brakes.

Another electric winding engine for the Harpener Company at Dortmund is also illustrated.* It is intended to wind 100 tons of coal hourly from a depth of 2296 feet. The pulley on the Koepe system is 19⅔ feet in diameter, and is coupled direct to a three-phase motor worked with current at 2000 volts. Liquid starting resistances are used.

Another type used at the Arnim collieries, Planitz, near Zwickau, Saxony, has two sets of drums, one behind the other, and each driven by direct-current motors. From 600 to 700 tons are wound daily from a depth of 722 feet. No starting resistances are used in the main circuit, but the current from the generator is controlled by regulating the exciting dynamo.

A description has appeared of an electric frictional winding engine, which was designed by T. Buschmann, and was exhibited at Düsseldorf by the Elektricitäts Gesellschaft.† It is driven by a slow-running continuous-current motor, and is capable of hauling a net load of 28 cwt. from a depth of 1300 feet.

A description is given of a gas-driven generating station for an electric winding engine. The installation consists of a complete Pintsch gas-producer plant working on the suction system and fed with coke. The generator is designed for a normal output of 100 horse-power, with a maximum of 125 horse-power, and it runs at 150 revolutions. The consumption of coke is 1 lb. per horse-power hour transmitted to the winding motor.‡

An illustrated memoir on electric winding plant has been written by O. Lasche.§

C. Köttgen ‖ discusses the methods of controlling electric winding engines.

* *Engineering*, vol. lxxiv. pp. 136-139; *Traction and Transmission*, vol. ii. pp. 52-54, with plate.

† *Glückauf*, vol. xxxviii. pp. 786-789.

‡ *Ibid.*, pp. 1000-1002.

§ *Ibid.*, pp. 700-704.

‖ *Elektrotechnische Zeitschrift*, 1902, pp. 601-607.

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The exhibits connected with winding shown at the Düsseldorf Exhibition have been described by Hecker.*

Winding Ropes.—H. Dechamps † discusses the application of graphic statics to the study of the equilibrium of winding ropes in deep shafts.

W. D. L. Hardie ‡ describes the various forms of wire ropes used in mines, and gives a specification for their manufacture and testing.

The statistics of the winding ropes in the Dortmund coalfield for 1901 have been published.§ Of the 462 winding ropes discarded, five were discarded as they broke suddenly, or 1·08 per cent. In 1872, when the statistics were first collected, the percentage was 19·30. During the thirty years, of the 7337 winding ropes discarded, 273, or 3·72 per cent., broke suddenly in use.

Details are published ‖ as to the replacement of wire ropes in the Breslau mining district. Of 194 ropes replaced, only two broke when in use. Iron wire ropes have not been employed since 1898, and now only round ropes of crucible cast-steel wire are used. In 1882 as many as 9·62 per cent. of the replaced ropes broke when in use, so that great improvements in this respect have since been effected, owing largely to the different nature of the material now used in their construction, and to round ropes having replaced flat ones.

Underground Haulage.—J. Baird ¶ describes the underground haulage at the Mossblown colliery, Ayrshire, which has only recently been sunk, and is not as yet fully opened up. The main haulage engines are placed at the surface, and work an endless rope haulage underground and also a main rope haulage on an incline. Full details and illustrations are given.

L. L. Logan ** describes an arrangement of sidings and crossings for a tail rope haulage plant.

B. F. Jones †† compares the various methods of underground haulage, and deals *inter alia* with the best sizes for trucks; resistance to haulage;

* *Glückauf*, vol. xxxviii. pp. 465–484, with twelve plates.

† *Revue Universelle des Mines*, vol. lviii. pp. 1–34.

‡ *Journal of the Canadian Mining Institute*, vol. v. pp. 33-41.

§ *Glückauf*, vol. xxxviii. pp. 911-912; *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. l. pp. 539-541.

‖ *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. l. pp. 315-316.

¶ *Transactions of the Institution of Mining Engineers*, vol. xxiii. pp. 155-162.

** *Mines and Minerals*, vol. xxii. p. 485.

†† Paperread before the Western Pennsylvania Central Mining Institute, June 1902; *Mines and Minerals*, vol. xxiii. pp. 8–12.

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soft coal mines, and refer to the use of direct currents and polyphase currents with and without transformers.

The fifth volume of the collective work * on the coal-mining industry of Rheinland and Westphalia, the whole of which is from the pen of W. Müller, forms a complete monograph on haulage. In the first chapter, on haulage materials, he deals with colliery waggons and colliery railways. In the second he describes haulage in levels (with putters and horses and with engine power), haulage on inclines, and haulage from dip workings. The third chapter is devoted to winding, detailed particulars being given of winding ropes, cages, guides, safety catches, signals, travelling in shafts, pit-head gear, loading, and winding engines. The last chapter deals with surface haulage; chain and rope haulage, locomotive haulage, and aerial wire ropeways being described in considerable detail. In the Ruhr coalfield there are nine such lines, those at the Pauline (1200 yards in length), the Neuglück (840 yards), and the Hasenwinkel collieries (2800 yards) being the most notable. At the first two collieries the ropeways bring coal from shafts on the right bank of the Ruhr to railways on the left bank. At the Hasenwinkel colliery coal and coke is carried to the Maria Anna colliery and there loaded on railway waggons. In the former cases an ordinary branch railway was not possible owing to the nature of the ground; in the last case the complete independence of the State railway and of the periodical shortage of waggons led to the construction of a ropeway. The capacity of the Hasenwinkel ropeway is 66 tons of coal and 30 tons of coke per hour. The buckets hold half a ton of coal. With a velocity of the hauling rope of 5 feet per second, the buckets follow at distances of 45 or 55 yards, so that there are constantly on the line 122 coal buckets and 100 coke buckets, of which half are empty and half are full. Details of the cost of the wire ropeway at the Neuglück colliery are given. It works out to £4, 4s. 2d. per metre. The cost of working, including interest and depreciation, is 2½d. per ton.

L. Hollein † states that at one of the collieries in the Karwin district an automatic switch has been employed on the tramways with much advantage owing to its simplicity and certainty of action. It connects several lines of rails, and the waggons pass from one to the other without any special alteration in the position of the switch being necessary.

* *Die Entwickelung des Niederrheinisch - Westfälischen Steinkohlen - Bergbaues*, vol. v., Berlin, 1902.

† *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. l. pp. 347–348, with three illustrations.

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H. Hoffmann * describes the mining machinery at the Düsseldorf Exhibition, with special reference to the application of electric driving.

The applications of electricity and power gas to mining as shown at the Düsseldorf Exhibition are described by R. Goetze.†

Compressed Air in Mines.—Some illustrations are given ‡ of a large King Riedler vertical air compressor built for the haulage plant at the Powell Duffryn colliery. Its capacity is 8300 cubic feet of free air, compressed in two stages to 60 lbs. pressure at seventy revolutions per minute with 95 lbs. boiler pressure. It is furnished with the King triangular connecting rods, which reduce the height of the machine by 11 feet as compared with the ordinary arrangement. The diameters of the steam cylinders are 23 and 38 inches, and of the air cylinders 23 and 37 inches; the stroke is 48 inches. Each side of the machine is a duplicate of the other, and can be uncoupled from the shaft and run separately. Whitmore's combined centrifugal and pressure governors are attached.

The air compressors exhibited at Düsseldorf are described by Müller.§

Explosives and Blasting.—In connection with the Düsseldorf Exhibition, Fähndrich ‖ publishes a lengthy article dealing with explosives and means of ignition.

H. Bigg-Wither ¶ insists upon the necessity for keeping detonators dry, and gives illustrations of lead plates on which damp and dry detonators have been fired. With damp specimens the copper tube is ripped open or blown into fragments which indent the plate, but with dry detonators the copper is blown into fine powder which scores the plate around the central indentation with fine lines.

A. P. H. Desborough, H.M. Inspector of Explosives, has issued his official report on the work carried out at the Home Office Testing Station for Coal-mining Explosives during the year 1901. The Permitted list now contains eleven nitro-glycerine compounds, eleven ammonium nitrate compounds, and three miscellaneous explosives. The working of the testing apparatus is described, and further tests have been made with coal dust.

* *Zeitschrift des Vereines deutscher Ingenieure*, vol. xlvi. pp. 811-816, 1149-1157.

† *Glückauf*, vol. xxxviii. pp. 605-616, with eleven plates.

‡ *Colliery Guardian*, vol. lxxxiii. pp. 1048-1049.

§ *Glückauf*, vol. xxxviii. pp. 577-583, with eight plates.

‖ *Ibid.*, pp. 717-734.

¶ *Transactions of the Institution of Mining Engineers*, vol. xxi. pp. 442-448.

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a quarter of the total production is won with the aid of these machines. The pick or percussive machines and the chain-breast machines are mostly used, though there are a few long-wall machines ; but the latter method does not meet with much favour in the United States. All the types in use and several that are of historical interest are illustrated, and several shearing machines are included.

R. Holiday * gives some notes on the application of three-phase currents to electrically driven coal-cutting machines with wheel, bar, and chain cutters. By the use of spring brushes sparking due to vibration at the rotor contact rings was avoided, and it was found possible to dispense with them and the starting resistances altogether, by arranging the gearing so that the motors could run freely for a few revolutions before beginning to drive the cutter. In one form this was done by a lug on a disc on the driving shaft engaging in either direction with a lug on the driven part after a partial revolution, so as to start the machine with a jerk. Short details are given of several machines used by the author, and their advantages are mentioned.

L. J. Daft † discusses the introduction and use of coal-cutting machines, especially from the point of view of the imperfection of the earlier designs and their recent improvement as affecting the workmen using them. Pick and chain machines are then discussed, preference being given to the former.

Some tests with coal-cutting machines at the mines of Marles, in France, are described in detail by Baily.‡ He comes to the conclusion that electrically driven cutters will not be widely adopted in the mines of Northern France.

Kier § gives an account of the results obtained with coal-cutting machines in the Ruhr coalfield. The trials were made with the Garforth machine, with the Ingersoll pick-machine, and with several types of German machines. The results show that with a hard or fairly hard coal the cost of production is considerably lessened.

E. Knackstedt ‖ discusses the advantages of coal-cutting machinery in reducing the quantity of slack coal. The use of rock-drilling machines as coal cutters is suggested.

At the mines of the Erzgebirgische Colliery Company, Saxony, the Münzner coal-getting machine was tried in several seams, but with

* *Journal of the British Mining Students*, vol. xxiv. pp. 171–174.
† *Mines and Minerals*, vol. xxii. p. 568 ; vol. xxiii. pp. 52–54, 87–88.
‡ *Bulletin de la Société d'Industrie Minérale*, vol. i. series iv. pp. 703–708.
§ *Glückauf*, vol. xxxviii. pp. 633–644.
‖ *Berg- und Hüttenmännische Zeitung*, vol. lxi. pp. 285–289.

is worked out to the boundary, and then the splint coal, 3¾ feet in thickness and 9 to 14 inches above it, is worked back on the long-wall system. Additional details of the methods employed in the neighbouring collieries are given by T. Moodie * and by T. Arnott;† generally speaking, they are similar in character.

D. Jones ‡ discusses the legislation and ownership of properties containing coal, especially in regard to the question of what steps should be taken to render available the coal beneath numerous small properties owned by different people. It is suggested that this matter might be considered by the Royal Commission on coal supplies.

A. S. E. Ackermann § compares the coal resources and methods of getting coal in England and America, and makes special reference to the shallowness of the workings in the latter country generally, as compared with those in England.

S. Wane ‖ describes a method of long-wall working in a seam 36 inches in thickness, with a soft roof and floor lying at an angle of 18°. The coal is worked with a stepped face on the full rise off main levels 60 yards apart.

In continuation of a general description of the coal deposits in the Loire basin, H. Pasquet ¶ discusses the character of the thin coal seams, in which category he includes all those below 10 feet in thickness. The first portion of the memoir is descriptive of the principal methods of winning the coal, and in the latter portion the methods employed are compared. In conclusion, some notes are appended on the working of fiery mines, as exemplified in the great Latour deposit near Firminy.

Stein ** publishes a number of notes on the conditions and methods of mining in Northern France.

For a long time past the Society of Mining Interests in the Dortmund district has had in preparation a collective work on the development of the coal-mining industry of the Lower Rhine and Westphalia. The second volume,†† which covers 378 pages, with 144

* *Transactions of the Institution of Mining Engineers*, vol. xxiii. pp. 282-287.

† *Ibid.*, pp. 288-290.

‡ *Ibid.*, pp. 272-278.

§ *Engineering Magazine*, vol. xxiii. pp. 357-362.

‖ *Journal of the British Society of Mining Students*, vol. xxiv. pp. 162-163.

¶ *Bulletin de la Société de l'Industrie Minérale*, series 4, vol. i. pp. 281-436, with seventy-four illustrations.

** *Glückauf*, vol. xxxviii. pp. 925-939.

†† *Die Entwickelung des Niederrheinisch-Westfälischen Steinkohlen-Bergbaues*, vol. ii., Berlin.

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deaths. The Austrian Government consequently appointed, on 22nd November 1900, a commission to inquire into the methods of mining employed in the Brüx brown coal region, and to ascertain what improvements were advisable. The report * covers 200 pages, and is accompanied by a map of the district and numerous illustrations. It is divided into seven sections, dealing respectively with (1) methods of mining, (2) ventilation, (3) mine fires, (4) fire damp and coal dust, (5) other noxious gases, (6) inrushes of water, and (7) technical management. Mining as carried on in the Brüx district, the Commissioners believe, is as satisfactory as it is in other important coalfields. They recommend, however, in certain cases some slight changes in the methods of working. For blasting, safety explosives should be used, and unless electric ignition is employed not more than one shot should be fired at a time. In fiery mines the maximum charge of explosive should be fixed by the inspectors of mines. It is also recommended that a permanent committee of experts should be formed to regulate the adoption of new inventions.

An illustrated and detailed account is given † of the collieries of the Webster Coal and Coke Company in the Johnstown basin at Ehrenfield, Pennsylvania.

A detailed account of the Indwe collieries, Cape Colony, has appeared.‡

E. W. Nardin § describes the Takasima collieries, which are worked from four small islands near the entrance to Nagasaki harbour, and gives numerous illustrations. The seams dip steeply, and are numerous and extensively faulted. A very large proportion of the workings are under the sea, and some five thousand workmen are employed above and below ground. A number of assays are appended.

F. J. Frank ‖ gives a short illustrated account of the Japanese collieries.

Mine Drainage.—The advantages and disadvantages of the various systems of pumping are discussed by F. Schulte.¶

W. R. Crane ** describes the construction of centrifugal pumps and their application to mining purposes.

* *Bericht der Commission zur Untersuchung der Betriebsverhältnisse des Bergbaues im Brüxer Braunkohlenreviere.* Vienna: Government Printer, 1902.
† *Mines and Minerals*, vol. xxii. pp. 433–437.
‡ *Colliery Guardian*, vol. lxxxiv. pp. 454, 509.
§ *Transactions of the Australasian Institute of Mining Engineers*, vol. viii. pp. 81–91.
‖ *Mines and Minerals*, vol. xxiii. pp. 49–52.
¶ *Glückauf*, vol. xxxviii. pp. 586–588.
** *Mines and Minerals*, vol. xxii. pp. 490–492.

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F. C. Haste * describes the pump, devised by himself, in which the barrel is reciprocated at a high speed, and works through stuffing boxes on the ends of the suction and delivery pipes. A double-ended conical valve lies in a swelled central portion of the barrel, and seats itself at one end or the other at the ends of the stroke, but leaves an annular passage during the back stroke equal in area to the pipes. The action of the pump, once started, depends on the inertia of the water column, but it may be considered as a form of bucket pump arranged so that there is a minimum of resistance to the continuous flow of the water.

The pumping engine at Bathgate, Linlithgowshire, is compound and condensing, the high-pressure cylinder being 38 inches in diameter and the low-pressure cylinder being 76 inches in diameter, each having a 9-foot stroke. The arrangement of the pumping engine is illustrated.† It is fitted with Davy's differential valve gear.

F. Darling ‡ states that an electric pumping plant has been put in one of the shafts in the South Durham collieries to replace the old Cornish pumps, so as to give more room for winding. A description of the plant at those collieries is also given.§

The application of electricity as a motive power in connection with pumping appliances is discussed by Hansen,‖ who describes a number of examples in which express pumps are so driven. Amongst these are the four pumps, each coupled to a 3000-volt alternating current motor, which were placed in position at the Colonia shaft of the Mansfeld Company, near Langendreer.

W. S. Ayres ¶ discusses some of the points which have arisen since the recent flooding of some of the anthracite mines in Pennsylvania owing to exceptional rainfall. The surface water is cared for to some extent by canals and ditches, and by flumes over broken ground. In some cases the surface has been filled in and raised by water-borne silt from operations on adjoining properties. Adit levels are also mentioned, and also raising the water by alternately filling and emptying two tanks at the bottom of the shaft with compressed air and water. It is becoming a usual practice to place the pumps in a chamber

* Paper read before the North Staffordshire Institution of Mining and Mechanical Engineers.

† *Colliery Guardian*, vol. lxxxiv. pp. 393-395.

‡ *Transactions of the Institution of Mining Engineers*, vol. xxiii. pp. 267-269.

§ *Ibid.*, pp. 264-266.

‖ *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. l. pp. 211-214.

¶ *Engineering and Mining Journal*, vol. lxxiii. pp. 378-379.

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discharge cone, the installation has worked regularly and effectively night and day. One man does the whole of the firing at the boiler, and at intervals inspects the fan. The automatically forced lubrication and the effective governors on the engine combine to render the whole installation reliable and steady, and it compares most favourably with other types of fans.

C. M. Percy * points out that about 20 tons of air are passed through the colliery for each ton of coal raised, and then gives an illustrated account of various fans used in English practice, especially the Guibal, Schiele, and Walker enclosed fans, and of the Waddle fan.

Dimensional illustrations are published † of a fan erected at a colliery at Glouster, Ohio. It is approximately 21 feet in diameter and 6 feet broad, and is driven by a single-cylinder direct-connected engine, with a 12 by 20-inch cylinder, giving 80 horse-power. An arrangement of passages and doors is provided, so that the fan may work either in blowing air into the mine or exhausting it.

An illustration is given by L. M. Hall ‡ of one of two 10 horse-power motors used in driving underground ventilating fans for local ventilation underground.

Electrically driven ventilating fans at the Mickley Coal Company's pits at Stocksfield-on-Tyne have recently been installed. The motors, of the continuous current type, are coupled direct to the fans, and develop about 300 horse-power at 500 revolutions per minute. §

The advantages of small fans for mine ventilation are advocated, and it is held that, in future, numbers of small inexpensive fans and engines will be used instead of large engines and fans which require special arrangements. With the greatly improved means of generating electricity at collieries, and the ease with which the current can be conveyed to different parts of the colliery, it is reasonable to suppose that small fans driven in this way will be fixed wherever required or driven by means of steam turbines.‖

F. Pospišil ¶ observes that the air pressure produced by the fans used in ventilating collieries gradually diminishes during the passage of the

* *Cassier's Magazine*, vol. xxii. pp. 394–408.

† *Engineering News*, vol. xlvii. p. 512.

‡ *Ibid.*, vol. xlviii. pp. 132-134.

§ *Iron and Coal Trades Review*, vol. lxv. p. 976.

‖ *Colliery Guardian*, vol. lxxxiii. p. 1324.

¶ *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. l. pp. 60-64, with two illustrations.

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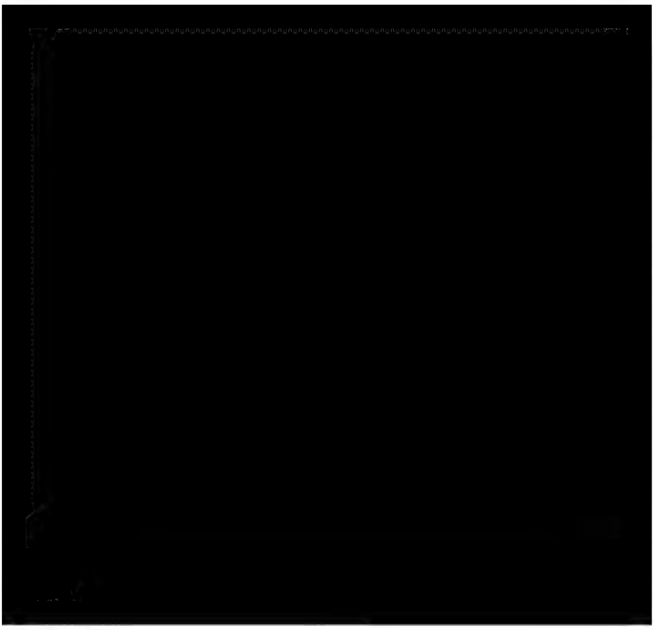
The tendency of the seams to make dust stands in a certain relation to the caking character of the coal. It is greatest in those seams where the coal is of a true caking character, and least in the case of the seams of gas and long-flamed gas coals, except these contain coals that will cake. The dust from the caking coals, too, is of a far more dangerous character than the other, and that dust has taken part in any large gas explosion has only been ascertained to be true in the case of that from coals which will cake. In 1862–63 the quantity of air passed through twenty-seven of the collieries of the Ruhr field averaged 77·7 cubic feet per man and per minute; in the case of forty-nine collieries in the years 1868–71 the average quantity was only 58·6 feet. These were results observed by official commissions, and another, which continued its labours until 1900, found that more than half of the collieries inspected during the years 1881–83 allowed less than 70·6 cubic feet of air per workman. Official regulations made in 1887 and 1888 required that this should be the minimum quantity per man, and that for each horse five times as much should be allowed. New regulations, which came into force at the commencement of 1902, require the ventilation to be such as to allow at least 106 cubic feet per man, and this must be yet further increased or the work stopped when over 1 per cent. of hydrocarbons is observed. Nearly all the collieries, however, considerably exceed these minimum quantities, the average amount in the case of the 210 shaft plants in 1900 being 176·6 cubic feet. The methods of ventilation in use are briefly referred to, and with regard to the fans in use it is stated that electricity is now often used as a motive power for those which are at a distance from the main plant. Of the older kinds of fans the Capell is most frequently employed, 102 of this type being in use. Of more modern forms the Rateau is most commonly met with, 42 of these being employed.

Fire-Damp Explosions.—L. Aquillon * has presented to the French Commission on fire-damp a report on the explosion which occurred in the Universal colliery in South Wales on May 24, 1901, by which eighty-one persons lost their lives. The official report of W. Galloway is referred to, and his conclusions are criticised.

Stanislas Meunier † deals with colliery explosions. He refers in highly complimentary terms to the underground photographs taken by Arthur Sopwith and Herbert W. Hughes.

* *Annales des Mines*, vol. ii. pp. 33–48.
† *Revue Scientifique*, vol. xvii. pp. 577–583.



conductor and wick. The connections to the coil are fixed in a stand, on which it is only necessary to place the lamp to light it.

J. Ashworth * illustrates several forms of safety-lamps, and discusses their use in relation to colliery explosions.

In the course of some comments † on one of the recent explosions, it is pointed out that more attention should be given to the safety of miners' lamps, and that watering dusty mines is not the only thing required to make a colliery safe. Several instances of explosions caused by lamps are quoted.

Leroyer ‡ advocates the use of benzine lamps in coal mines. He describes the most suitable form of lamp and the method of storing the benzine.

He § also describes the benzine safety-lamps used at the Liévin colliery.

An account is published by Rössner ‖ of a benzine safety-lamp which was first introduced into the Ostrau-Karwin district in 1898. It was brought out by the firm of H. Hübner, of Hermsdorf. In appearance, it closely resembles the Wolf benzine lamp. The benzine chamber, however, is stamped out in a single piece, and this is a distinct advantage, as not only does greater lightness result, but it possesses great strength and resistance to damage caused by external force. The lamp is provided with a patented igniting attachment. At the Hohenegger shaft in the Karwin field, since 1898, 400 of these lamps have been gradually introduced, and recently 200 others have been ordered in addition, the results they have given in practice having been most satisfactory.

Fähndrich ¶ describes the various types of safety-lamp shown at the Düsseldorf Exhibition. Illustrations of miners' electric lamps are given, and of machinery for the cleaning and testing of safety-lamps.

Accidents in Mines.—Some notes are published by A. Halleux ** upon the accidents due to the use of electricity in Prussian mines, their causes, and the precautions to be observed for their avoidance.

The third instalment of the report of the Prussian Commission on

* *Journal of the Canadian Mining Institute*, vol. v. pp. 379-392.

† *Engineer*, vol. xciii. pp. 506-507.

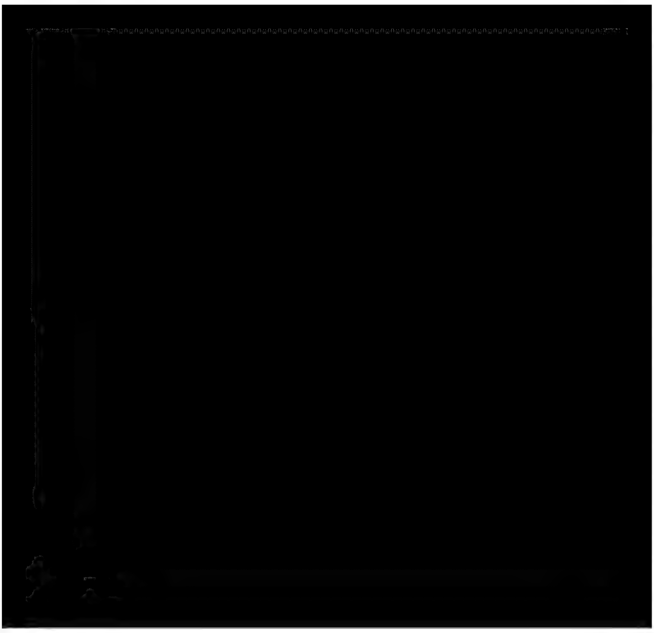
‡ *Bulletin de la Société de l'Industrie Minérale*, vol. i. series 4, pp. 779-816.

§ *Comptes Rendus de la Société de l'Industrie Minérale*, 1902, p. 164.

‖ *Oesterreichische Zeitschrift für Berg- und Huttenwesen*, vol. l. pp. 255-257, with four illustrations.

¶ *Glückauf*, vol. xxxviii. pp. 717-734, with two plates.

** *Annales des Mines de Belgique*, vol. vii. pp. 305-311.



is assigned to Philip Lebon (whose patent is dated September 28, 1799), and in England to William Murdoch, who applied gas lighting at Boulton & Watt's foundry in 1798.*

Mine Surveying.—D. D. Scott † has given a most accurate and impartial history of the development of mine surveying. Its value is enhanced by copious references made with studious care, and with numerous illustrations of early and recent forms of instruments of all kinds.

G. R. Thompson ‡ describes the methods of connecting underground and surface surveys by the magnetic needle, transit theodolites, and transit instruments, plumb lines in one and two shafts, and by inclines.

T. H. B. Wayne § describes a method of connecting underground and surface surveys. A collapsible triangular frame is fitted with levels and legs, so that it can be supported horizontally. A telescope and vernier are placed at the apex, and the two legs are recessed at their ends to fit loosely round the two plumb lines. If the telescope is clamped to a sight at one level, the frame may be transferred to another level where the telescope will give the same direction.

Several new types of hand-surveying instruments, consisting of adaptations of Sir Howard Grubb's gun sight, are illustrated.‖ They include inclinometers, hand levels, and prismatic compasses.

H. W. Dubois ¶ describes the use of ordinary cameras in accurate photographic surveying, and calls attention to the method of triangulation which can be carried out in mountainous regions with a good camera. A. O. Wheeler ** gives some notes on the field work of photographic surveying as applied in Canada. A number of the photographs are reproduced to show the methods of plotting from them, and the details of the work are described generally.

F. W. McNair †† discusses the divergence observed in the plumb lines at the Tamarack mine, and as the results of experiments ascribes the phenomena to the effect of air currents.

* *Rassegna Mineraria*, vol. xvii. pp. 185-186.

† *Transactions of the Institution of Mining Engineers*, vol. xxiii. pp. 575-621.

‡ *Ibid.*, vol. xxii. pp. 519-535.

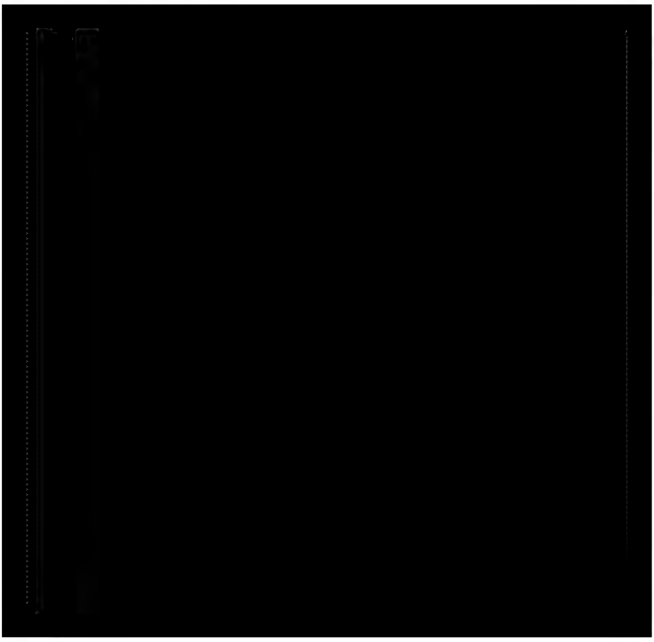
§ *Mining Journal*, vol. lxxii. p. 911.

‖ *Engineering*, vol. lxxiv. pp. 33-34.

¶ *Transactions of the American Institute of Mining Engineers*, Philadelphia meeting, May 1902.

** *Transactions of the Institution of Mining Engineers*, vol. xxi. pp. 418-439.

†† *Electrical World*, vol. xxxix. pp. 721-723; *Engineering and Mining Journal*, vol. lxxiii. p. 578.



the lower end and dirt at the top. The washed coal is led into circular tanks, from which water is led by a square trunk with gauze on one side. The coal and the gauze filter the water, which passes away clean. An experimental plant at Coanwood, Northumberland, reduced the dirt from 25 to 5 per cent., and from 11 to 5 per cent. in another sample. Two other plants are at work, and one is building. Each table treats 40 to 70 tons in ten hours.

The Campbell coal washer, which is also of the shaking or bumping table type, is described by C. R. Claghorn.* The table or box, 9 or 10 feet long and 30 inches wide, is hung at a slight inclination by its corners, and has a stroke of 6 to 8 inches. Coal and water are fed to the centre of the table; the dirt is discharged at the top and washed coal at the lower end. The capacity of each table is 5 to 7 tons of washed coal per hour, at an expenditure of about ½ horse-power. The sizing of the raw coal is of considerable importance. In one test with 1500 tons of Vinton coal, 93·9 per cent. of washed coal and 6·1 per cent. of dirt were obtained.

A plan is given of the coal screening and washing plant at Mosside pit, Bathgate, Linlithgowshire, to show the arrangement of jigging screens and belts.†

The washing appliances at the Mosside colliery are also illustrated.‡ The coal is made into four sizes and washed in felspar bashes.

E. Lefévre§ gives a detailed description, with illustrations, of the new coal-washing plant installed at the Azincourt mines.

The exhibits connected with coal washing and briquette manufacture at the Düsseldorf Exhibition are described by Wendt.‖

The Preparation of Anthracite.—Illustrations are given by G. L. Carlisle¶ of the new breaker erected at Nanticoke, Pennsylvania. The building is 165 feet in height to the top of the hoisting tower, and only 60 feet wide in the widest part. It is largely built of cast iron, wrought iron, and steel, and is intended to treat 500 to 700 tons daily. All the machinery is driven by separate electromotors instead of belting. The slate and coal are separated in spiral pickers, of

* *Transactions of the Institution of Mining Engineers*, vol. xxiii. pp. 435–445, with one plate.

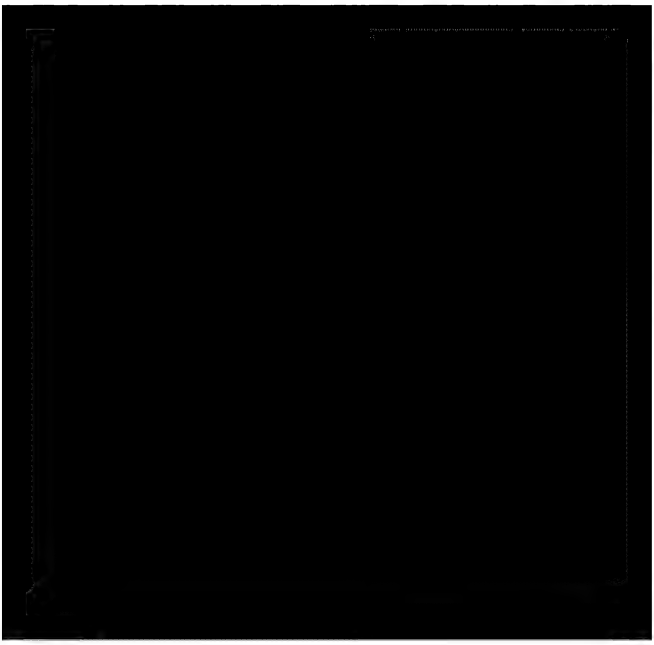
† *Colliery Guardian*, vol. lxxxiv. pp. 393–395.

‡ *Ibid.*, pp. 505–506.

§ *Echo des Mines*, vol. xxix. pp. 778–781.

‖ *Glückauf*, vol. xxxviii. pp. 661–679.

¶ *Mines and Minerals*, vol. xxiii. pp. 80–84.



the coal more liable to chemical change, and the loss in the calorific value has been placed as high as 10 per cent. The mechanical influences are no doubt more deleterious, and Stelkens gives many particulars of the percentage of breakage in different kinds of Westphalian coal under varied conditions. Coke suffers also, but to a less extent mechanically, but storage is decidedly injurious. The various means of handling coal also receive some attention.

J. Macaulay * states that the coal which falls into the docks at Newport is dredged up periodically, and is not found to have suffered much loss in calorific value. Some tests made on samples immersed in sea water for two months showed that there was only a loss of 0·8 per cent. in value. It is therefore suggested that coal for naval purposes should be stored under sea water in special tanks in order to avoid the loss which follows on exposure to the air. An investigation has been ordered.

Briquettes.—W. G. Irwin † describes the fuel briquetting industry in the United States, and ascribes its comparative failure to the large supplies of natural fuel available in the country. The waste in the early years in the anthracite districts has now been greatly reduced, partly by improved methods of mining and partly by the better utilisation of small sizes; but still there are vast quantities available for briquetting. Many plants have been started, and of these a short account is given. Pitch has generally been used as a binding material, but is objectionable on account of the smoke from it, and its cost has varied so greatly. In more recent practice many endeavours have been made to use some vegetable binding agent with more or less success, and many of the existing plants are making eggettes. Improved methods of washing and preparation have also contributed to the success of this kind of fuel.

Steger ‡ discusses the value of the several materials employed as binding agents in the manufacture of briquette fuel.

Roux § discusses the employment of petroleum in the manufacture of coal briquettes.

C. Kegel ‖ describes the preparation of brown coal briquettes.

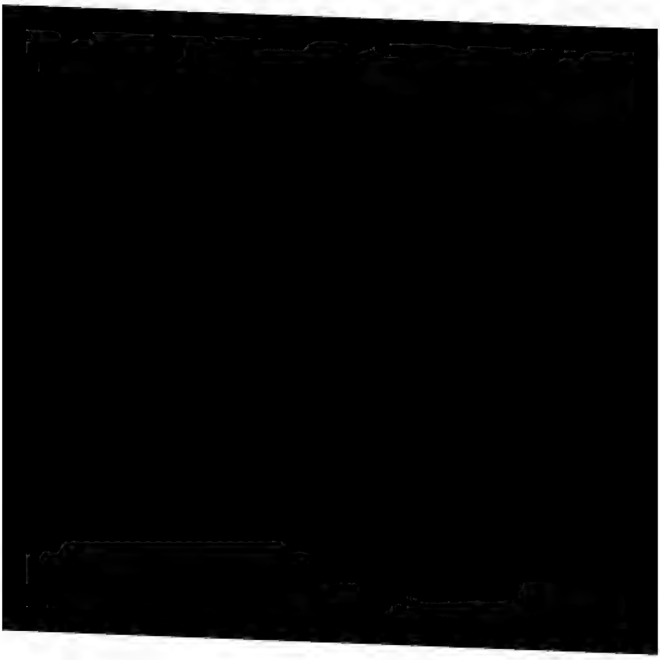
* *The Times*, September 1, 1902; *Colliery Guardian*, vol. lxxxiv. pp. 517, 528.

† *Iron Age*, June 19, 1902, pp. 19–22.

‡ *Zeitschrift für das Berg-, Hütten- und Salinenwesen im preussischen Staate*, vol. l. pp. 311–320.

§ *Chemiker und Techniker Zeitung*, vol. xx. No. 1.

‖ *Glückauf*, vol. xxxviii. pp. 645–647.



PRODUCTION OF PIG IRON.

CONTENTS.

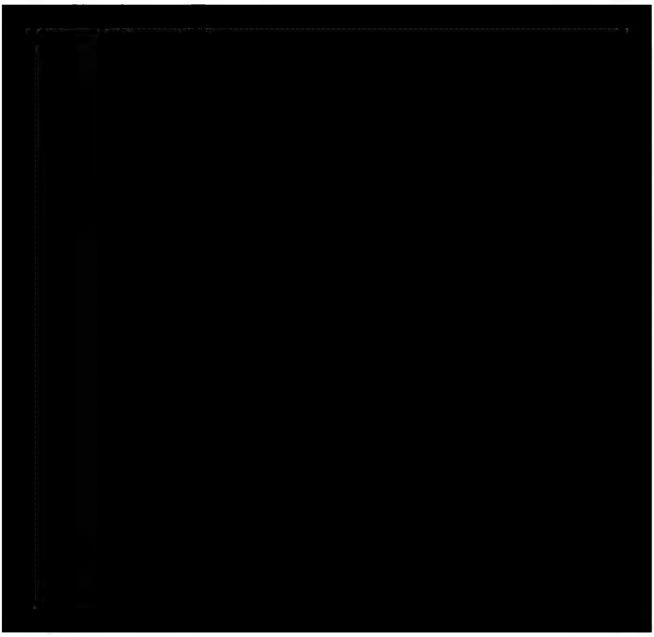
I.—*BLAST-FURNACE PRACTICE.*

Design and Equipment of Blast-Furnaces.—A series of articles on the designing and equipment of blast-furnaces by J. L. Stevenson * is now being published. The first deals with the hot-blast stoves, and especial attention is directed to the necessity for a large heating surface. The size of the stoves should be uniform, and four stoves are preferred to two or three of larger diameter. Two tables are given for full chequered stoves and Whitwell stoves, showing height, diameter, heating surface, duty capacity per stove, and size of chequer work, and illustrations are appended of several forms. An output of 400 tons per day would require not less than 180,000 square feet of heating surface divided amongst four stoves. Regularity in the blast temperature is essential, and to obtain it use may be made of the Harrison-Gjers equaliser or of a thermostatic appliance which controls the opening of a valve in the supplementary cold-blast supply pipe. This appliance is also illustrated.

J. M. Hartman † gives some brief notes, partly historical, on the construction of blast-furnaces, and gives five figures to show the method of building and supporting the body of the furnace in 1854, 1861, 1878, and 1885. The lining itself and the backing for it receive attention.

B. D. Healey ‡ gives some notes on blast-furnace practice, and com-

* *Engineer*, vol. xciv. p. 248.
† *Iron Trade Review*, May 8, 1902, p. 42.
‡ Paper read before the Society of Engineers, May 1902.



the choice of a site for ironworks, and then passes on to a comparison of British and American progress. The cost of transport in the two countries is considered, with the result that the British manufacturer is shown to be labouring under a great disadvantage in this respect, the cost of transport in Great Britain being about four times greater than in America. A review of the progress of foreign iron-producing countries is then given, and the remarkable backwardness of British colonies in this industry is commented on, it being pointed out that Canada is at present almost the only colony in which iron manufacture is carried on to any extent, though attempts have been, and are being, made to establish blast-furnaces in other colonies, some of which possess particularly rich deposits of iron ore of a good class. After briefly considering the question of fuel for the blast-furnace, some remarks are made on the choice of position for the blast-furnace, and the class of ore which can be most economically employed is discussed.

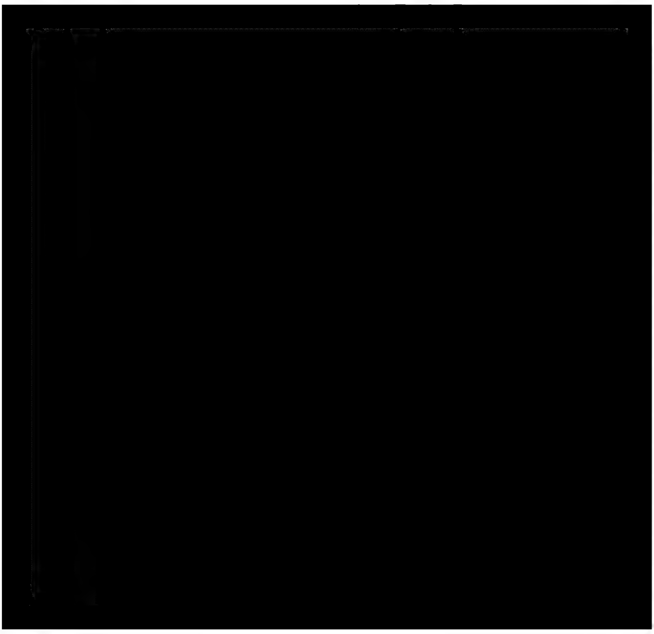
The Valuation of Iron Ores for Blast-Furnace Charges.—C. Rosambert* discusses the question of the valuation of iron ores, and, referring particularly to the paper on this subject by P. List,† observes that he does not consider the formula proposed by the latter to be altogether accurate. Where more limestone is required more fuel must also be used, and of this the formula takes no consideration. In calculating the relative values of two ores this may lead to very considerable error. To prove this the author takes the case of two ores containing:—

	A	B
	Per Cent.	Per Cent.
Ferric oxide	67·90	67·90
Silica	17·90	10·60
Alumina	5·00	4·00
Lime	3·00	11·30
Sulphur, phosphorus, volatile constituents, &c.	6·20	6·20

The ore A would need per ton about 0·3 ton of good limestone, while ore B would be self-fluxing, the ash in the coke not being taken into consideration. It is therefore evident that, under otherwise similar conditions, the consumption of fuel in the treatment in the blast-furnace

* *Stahl und Eisen*, vol. xxii. pp. 503-505.

† *Journal of the Iron and Steel Institute*, 1902, No. I. p. 520.



of the iron produced from the ore. The various constituents of an ore either increase or diminish its value, and, in the latter case, lead to limitations in its use. Thus, an ore containing 0·2 per cent. of phosphorus can only be used at the most to the extent of 10 to 15 per cent. in the production of pig iron containing 0·1 per cent. of phosphorus. A few tenths per cent. of manganese may be of the utmost importance in connection for converter purposes, and yet the same general market name would be used for this as well as other kinds. The same holds true in the case of the phosphorus.

Dealing in detail with the cost of the ton of pig iron, the author in the first instance considers the cost of the ore, and shows in tabular form the quantities of ore, varying from 20 per cent. of iron to 68 per cent., that are required for the ton of pig iron containing from 91 to 95 per cent. of iron; the loss of iron in the form of dust and in the slag being also shown. The dust amounts to about 5 to 20 grammes per cubic metre of blast-furnace gas, and its iron contents from 12 to 45 per cent. A table showing the loss of iron in the form of dust for different quantities of dust and iron contents is also given, together with the percentage loss on the iron contents of the ore. The loss in the form of slag is, as a rule, more or less counterbalanced by the iron contents of the ash of the coke.

The other subdivisions of cost of production are similarly dealt with, and a number of useful tables are also given, most of which, however, are also published in *Stühlen's Ingenieur Kalender*.

The author takes a series of typical examples, and draws up a thermal balance-sheet for them, dealing with this subject in considerable detail, basing his calculations, among others, on the following data:—

To reduce 1 Kilogramme.	Thermal Units required.
Fe from Fe_2O_3	1796
Fe ,, FeO	1352
Mn ,, Mn_3O_4	2273
Mn ,, MnO	2000
Si ,, SiO_2	7830
P ,, P_2O_5	5760

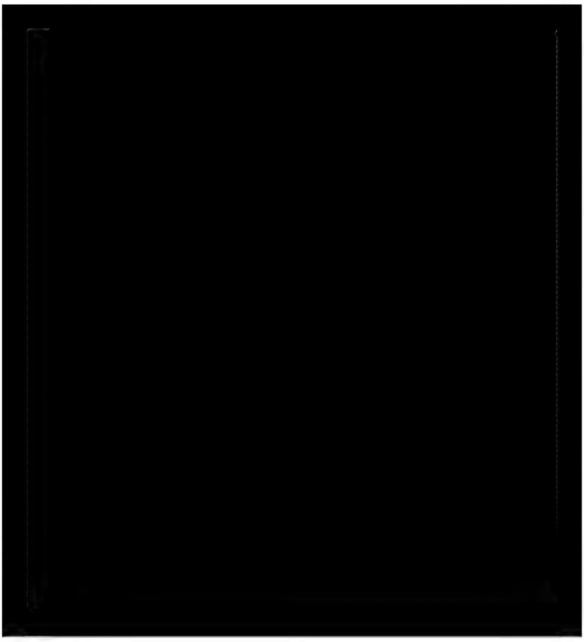
The thermal units required to fuse 1 kilogramme of slag are from 400 to 500; to fuse 1 kilogramme of pig iron, 250 to 350; to expel 1 kilogramme of carbon dioxide, 943; to expel 1 kilogramme of water of hydration, 721; and to drive off 1 kilogramme of moisture, 636.

The following is one of the examples of the calculations given by

corresponding to 111 kilogrammes of coke. This quantity would suffice with good strong coke and lump ore. As a rule, however, an additional 5 per cent. of coke would be needed, and this addition would always be necessary if pig iron containing 3 per cent. of silicon is to be continuously produced.

Stock Indicator for Blast-Furnaces.—A more careful watch, Neumark * observes, has now to be kept over blast-furnace processes generally, in view of the constantly increasing requirements of modern practice. Large production, saving in fuel, and a thorough utilisation of the blast-furnace gases, can only be attained by carefully watching the furnace charges, not only as regards the quality of the materials, but also as to how and when these are charged, and how quickly the furnace throat is open and closed again. Every purely personal control is, however, faulty, and the author now describes an apparatus the use of which admits of a perfect control. Personal supervision is no longer necessary at all, as the apparatus can be put up in the works' office and cannot be tampered with, while it gives a complete record of what is happening at the throat of the furnace. As a rule, the author observes, it is desired to know: (1) How many charges have been made, (2) At what times were they charged, and (3) How many seconds was the furnace throat open at each charging. The second appears to be more important in regulating the working of the furnace, as it is most important that this charging should be done with regularity and not spasmodically. The author has devised an apparatus in which a pencil is made to give a record on a rotating drum, both being moved by clockwork apparatus. The drum remains at rest as long as the furnace remains closed, but begins to rotate as soon as the furnace is opened, an electric contact being then made, which sets free a brake on the drum. The drum continues to rotate until, the furnace being closed, the current is broken, and the brake comes into action again. A diagram is shown which resulted from actual practice. This is remarkably clear, and it shows that the coke took far less time to charge than the ore, each coke charge seldom requiring the furnace to be open for more than 15 seconds. In the case of some of the ore charges, the furnace was left open unusually long, the third in the night shift having taken up 63 seconds, and the sixth in the day shift 50 seconds. During the 24 hours the bell was open for 25 minutes in all, each charge necessitating on the average 26·8 seconds. The bell was raised by steam power.

* *Stahl und Eisen*, vol. xxii. pp. 816–817, with two illustrations.



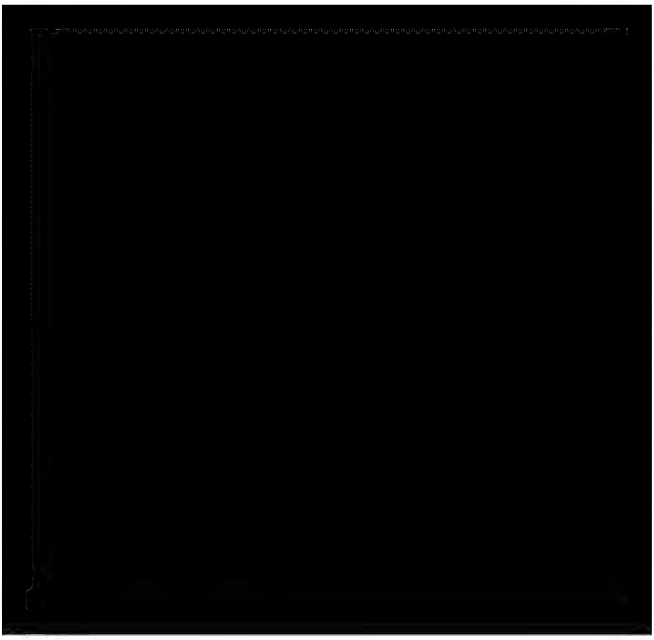
a double take-off is also projected. This will consist of a Lange bell with a cover.

Motive Power from Blast-Furnace Gases.—The utilisation of blast-furnace gases to drive gas-engines for the production of power is dealt with in a paper by Bryan Donkin.* The subjects considered include the composition of blast-furnace gases, the utilisation of blast-furnace gases, the disadvantages of blast-furnace gases, large gas-engines, history of the utilisation of blast-furnace gases in gas-engines, single cylinder and multiple cylinder engines, and the Oechelhäuser gas-engine.

H. A. Humphrey † reviews recent progress in the manufacture and use of large gas-engines, and describes more or less in detail the different types of the several makers. A list of gas-engines over 200 horse-power, delivered or in hand, shows 238 with an aggregate of 98,955 horse-power for driving dynamos, and 89 with an aggregate of 82,650 horse-power for other purposes. More than 50 are given as rated at 1000 horse-power or above, and two American engines are stated to be of 4000 horse-power each. A number of illustrations are given, and a large amount of information as to the types and their makers.

Great progress has been made in the construction of gas-engines for the utilisation of blast-furnace gases.‡ The difficulties at first met with were due rather to an inadequate purification of the blast-furnace gases than to faults in the gas-engines employed. Now, however, that it has been found possible to clean the gases in a simple and rational manner, the difficulties at first experienced no longer exist, and the gas-engines working with blast-furnace gas run smoothly and keep at work uninterruptedly for months at a time. Their consumption of gas, too, is low; and, commercially, the use of the gas in this way has proved most successful, a considerable saving being effected when compared with the boilers and steam-engine plants previously employed. It is probably only a matter of time before all these will have disappeared in the iron industry. Which exactly is the best of all the various types of engines for blast-furnace gas is not yet certain, as some of these have only been in operation practically for a relatively short time. The older and simpler form seems, however, so far to be

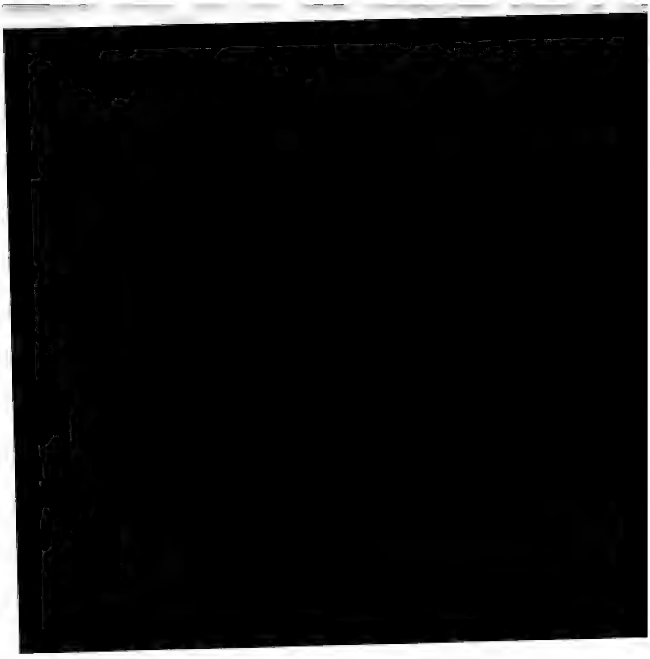
* *Minutes of Proceedings of the Institution of Civil Engineers*, vol. cxlviii. pp. 1-55.
† Paper read before the British Association; *Engineering*, vol. lxxiv. pp. 375-378, 426-427, 458-460, 520-523; *Nature*, vol. lxvi. p. 643.
‡ *Stahl und Eisen*, vol. xxii. pp. 420-424, with eight illustrations.



its original work, and was found to have been strongly encrusted. After being cleaned it worked again as well as it did at first. If the gas is under pressure much poorer results are obtained. The inventor of the apparatus, in dealing with these results, points out that the reason why the apparatus did less and less work after being in operation some time was due to the choking up of the gas inlet, and was not due to any fault of the apparatus itself. He adds that this washes itself clean if an adequate quantity of clean water is passed through it. The apparatus in this case needed more power than had been anticipated, but, on the other hand, it washed the gas cleaner than it had been guaranteed to do.

F. W. Lürmann * observes that, apart from the works at Hörde and at Differdingen in Luxemburg, there is probably scarcely any other which has so fully developed the utilisation of blast-furnace gases as the Ilsede works. This works has always utilised the waste heat from coke ovens for evaporating 3·1 lbs. of water per square foot per hour, the total boiler heating surface being 15,608 square feet. In addition the works had excellent arrangements for the better combustion of blast-furnace gases under boilers, and of late improvements have been made in the construction of the hot-blast stoves, by which a considerable saving has been effected in the quantity of gas which these require. Before the direct utilisation of blast-furnace gases in large gas-engines was employed in Germany, the Ilsede works in 1899 laid down fourteen large boilers to utilise such gas, and these supplied steam to five steam-engines of a total power of 1820 horse-power. These are used to drive large dynamos, which together yield 1200 kilowatts at a pressure of 500 volts. For lighting purposes the works use 90 kilowatts, and for other purposes 60 kilowatts. The remainder is transformed into a current of 10,000 volts. Of this 100 kilowatts is sent to the iron ore mines at Gross-Bülten, 2·2 miles away, where it is used for lighting purposes, for an underground Riedler express pump, for a mine engine, six rock drills, rope-way, repairing shops, &c. The remaining 950 kilowatts is sent to the Peine rolling mills, which are about 4 miles distant, where it is used for power and for lighting. At the same time that this central electric power station was erected, experiments were commenced with a 60 horse-power Deutz gas-engine, using blast-furnace gas. The results were so satisfactory that a blowing engine, driven by an Oechelhäuser gas-engine, was put into opera-

* *Stahl und Eisen*, vol. xxii. pp. 898–901, with one illustration.



gether, and the top is tied by 10-inch I-beams. The bottom is stiffened by 12-inch I-beams. The bottom of the tank is circular, and runs on rollers. The roof is arched in both directions, and is lined with 14-inch brickwork, 18 inches of brickwork being used in the bottom. The mixer has a wide mouth, through which all slag can readily be removed. Oil burners are used for heating.

The judgment of the Supreme Court of the United States has appeared * in the case of the Carnegie Steel Company (Limited) *versus* the Cambria Iron Company, for infringement of the Jones mixer patent. It was held by the majority of the Court that the patent was valid, and that there had been infringement. A dissenting opinion by four of the judges directly traverses this judgment, however. The history of the process and the alleged anticipations is given in full in both instances.

Slag and Metal Ladles.—In a recently published account † of various types of slag and metal ladles, illustrations are given of the following forms: Self-tipping slag bogies at the Barrow works; Stevenson & Evan's slag ladle; Dewhurst's ladles, early type and tipping type and side-tipping type; the Junkerath slag ladle; 16-ton Treadwell slag ladle; Weimer slag ladle; Hartmann ladle; Stevenson ladles of various sizes for metal; Neeland ladle; Cresson ladle; Hunt ladle; Barrow side-tipping ladle; and Jones & Laughlin's metal ladle.

Illustrations are given ‡ of a slag ladle mounted on a truck, and designed to carry 16 tons or 200 cubic feet of slag. The ladle is mounted on trunnions set fore and aft, carried by two bogies, which are connected by a heavy underframe under the ladle. Pinions are mounted on the trunnions, and roll on racks, so that the ladle is shifted laterally as it tilts, and thus discharges the slag clear of the frame. The tilting is done by a single man in two minutes by means of worm gearing. Five of these ladles, each of which weighs 30 tons, are in use.

Illustrations are also given § of a 6-ton slag ladle with similar rolling trunnions.

C. Machacek ‖ refers to the extent to which electricity is now

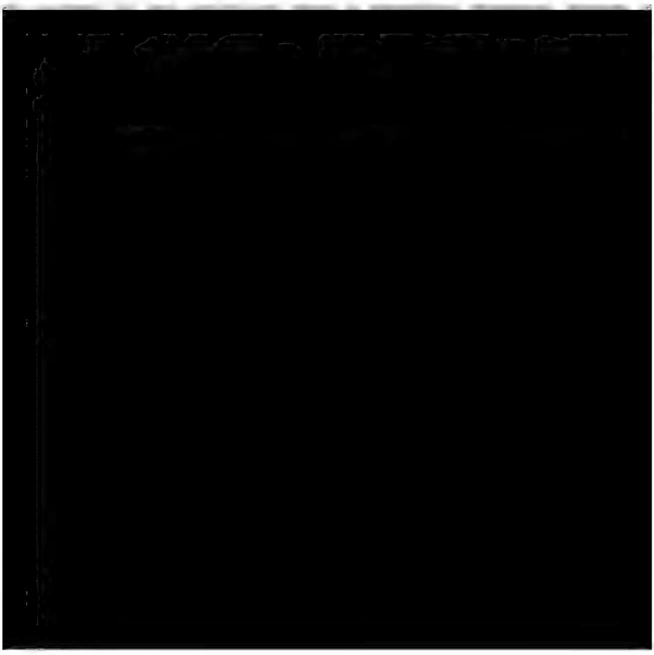
* *Official Gazette of the United States Patent Office*, vol. xcix. pp. 1866-1870 *et.*

† *Iron and Coal Trades Review*, vol. lxv. pp. 849-852, 913-916.

‡ *Engineering News*, vol. xlvii. pp. 444-445; *Iron Age*, August 14, 1902, pp. 14-15.

§ *Iron Age*, July 3, 1902, pp. 1-2.

‖ *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. l. pp. 139-144, with two plates.



Bosnia.* The mineral riches of Bosnia and Herzegovina were known in prehistoric times, but it is only since these countries came under Austrian rule in 1878 that mining has been followed on any important scale. Before that time the iron industry was carried on in a most primitive way, an illustration being given of the form of furnace and bellows blowing engine then in use. For 1 ton of iron made, from 3 to 5 tons of charcoal was employed.

Iron ore is found at Vares in the Trias. The beds reach 110 yards and more in thickness, and have been observed along their strike for a distance of over 3 miles. So far they have been won solely open-cast, and in these workings the ore reserves amount to 10,000,000 tons. Larger quantities could be obtained by deep mining. At the deposit at Smreka 130,000 tons of ore was mined, of which 80,000 tons was smelted at the Vares works. The ores met with are of various kinds, the best being the red hæmatites of Przici, which contain 60 per cent. of iron and some manganese. The following two analyses are given of this ore, as well as others of the other kinds of ore met with :—

	I.	II.	III.	IV.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Iron	65·07	61·20	48·70	45·90
Manganese	0·53	0·11	2·00	5·08
Silica	4·14	6·05	6·28	6·55
Lime	0·48	0·35	0·70	...
Magnesia	0·26	...	0·39	...
Alumina	1·00	0·68	1·35	...
Baryta	...	3·00	3·03	...
Sulphur	0·04	0·16	0·12	0·30
Phosphorus	...	0·08	0·25	0·02
Copper	0·01	trace	0·26	0·02

No. I. is stated to be a red, and No. II. a blue hæmatite, both from Przici; No. III. a limonite, from Bresik; and No. IV. a siderite, from Droskovich.

The new charcoal blast-furnace at Vares came into operation in January 1900. For the first month foundry iron was made, and then for the next six months from 75 to 80 tons of white pig iron was made daily, the ores smelted yielding 52 to 53 per cent. of iron. In 1901 greater stove facilities enabled a blast temperature of 850° C. to be attained, with the result that the output increased so considerably that in May 1901 the average daily output was

* *Stahl und Eisen*, vol. xxii. pp. 490-492, with four illustrations.

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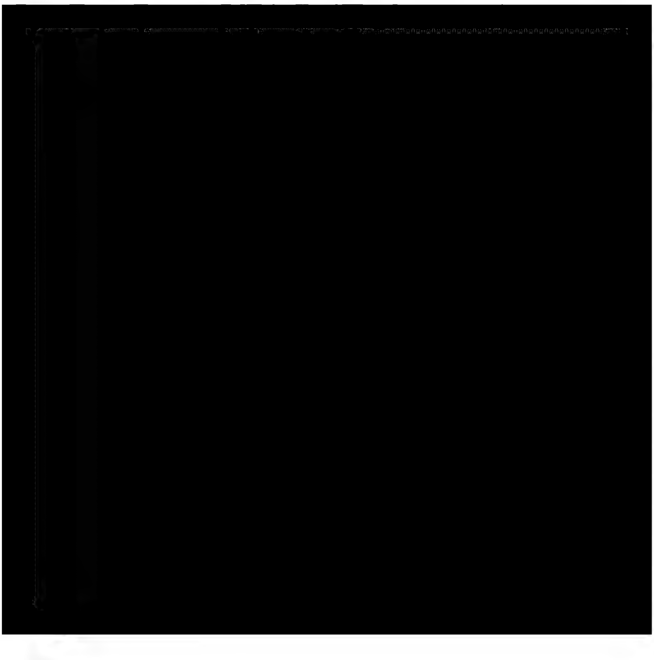
The Skinningrove Blast-Furnaces.—An illustrated account of the works of the Skinningrove Iron Co. has recently appeared.* The coke is brought 30 or 40 miles from the Durham field, limestone from Pickering in Yorkshire, and ore from the Cleveland district, in the centre of which the furnaces are situated. The ore is hand-picked at the mine on a belt 160 feet in length and 6 feet broad, travelling at 60 feet per minute, and is calcined in kilns before use. The furnace plant consists of five furnaces, one being kept in reserve. One of these was built in 1901, with eight instead of six tuyeres, to produce 800 tons weekly. The blast pressure is kept low, at 6 to 7 lbs. per square inch. There are two lifts, one to each pair of furnaces, and ten calcining kilns. The new kilns have been built and the old ones raised to a higher level, so that the barrows run by their own weight to the lifts. Limestone is mixed with the ore and calcined with it. The stove equipment consists of eleven Cowper stoves. Slag is carried to the waste heaps by 12-ton side or end tipping ladles, and fluid slag is tipped. A travelling crane commands the pig beds, and serves for the removal of the pigs after they are broken. An automatic recorder is used to note the times of charging the blast-furnaces.

The Esch Blast-Furnace Plant.—The blast-furnaces at Esch and the steelworks at Rothe Erde belong to one German company, the Aachener Hütten Actien-Verein.† The blast-furnace plant at Esch-on-the-Alzette consists of five large blast-furnaces, which have an annual capacity of 360,000 tons of basic Bessemer pig iron. They are provided with eight blowing engines of 8300 total horse-power, two being gas engines with a joint power of 1200 horse-power. The Rothe Erde steelworks comprises a basic Bessemer plant with three converters, capable of making some 300,000 tons a year, and an open-hearth plant with three 25-ton furnaces, and an annual capacity of 70,000 tons of ingots. The rolling mill has thirteen trains of rolls, of which two are large ingot mills. The workpeople employed at these several works number between five and six thousand.

Smelting Gellivare Ores.—According to Leo,‡ extensive experiments have been carried out in fourteen Swedish blast-furnaces with Gellivare ores and concentrates, during which no stoppage of any kind

* *Iron and Coal Trades Review*, vol. lxv. pp. 657-659.
† *Stahl und Eisen*, vol. xxii. p. 831.
‡ *Zeitschrift des Oberschlesischen Berg- und Hüttenmännischen Vereines*, 1902, pp. 374-376.



labour conditions generally of the blast-furnace industry. A table comparing wages in England and the States is an interesting feature of this section. In conclusion, the author presents his views upon the possible future markets for American iron and steel.

W. L. Cowles * describes the appliances for handling ore at the new Carrie furnaces, Rankin, Pennsylvania. The ore is discharged from the railway trucks by tipplers into a bin under which buckets mounted on electrically driven trolleys run and are loaded. The buckets are picked up by a Brown hoisting machine and discharged on to ore piles in the stock yard or into another bin, from which the furnace skips are loaded. These skips run up an inclined hoist to the top of the furnace, and are discharged automatically by tilting them on to the furnace double bell. The various appliances are illustrated by a number of excellent photographic reproductions.

At Thomas, Alabama, No. 3 furnace has recently been blown in. It is 85 feet in height and 18½ feet in diameter at the boshes and 12 feet in the hearth, and its daily capacity is given as 250 tons. It has twelve 6-inch tuyeres placed 8 feet above the hearth, and has copper and iron cooling blocks. Gas is taken by two 6-foot downcomers through a dust catcher and washer on its way to the boilers. Four Massicks and Crookes stoves, 22 by 85 feet, are provided.†

An illustrated description and plans have appeared ‡ of the Minnequa steelworks at Pueblo, Colorado. Three new furnaces, 95 by 20 feet, have recently been built and fitted with skip hoists. Bridges and grab buckets are used for handling the ore, and ore and coke steel bins with inclined bottoms are used. Two skips, each holding 150 cubic feet, run on the inclined hoist, which is arranged so that one passes over the other at the centre, and the hoisting ropes are worked by electromotors. A 15-ton trolley commands the bells and blast-furnace top. Four Cowper stoves, 21 by 106 feet, serve each furnace, and blast is supplied through ten 6 or 7-inch tuyeres. The metal is taken to two 300-ton mixers, which supply the Bessemer and open-hearth plant.

Illustrations are given § of the conveyer bridges for stocking ore at the furnaces on Neville Island in the Pittsburg district.

History of Iron.—J. Birkinbine ‖ compares the old and the new

* *Cassier's Magazine*, vol. xxii. pp. 157–174.
† *Engineering and Mining Journal*, vol. lxxiii. p. 858.
‡ *Iron Age*, August 14, 1902, pp. 1–11.
§ *Iron Trade Review*, May 8, 1902, pp. 28–29.
‖ *Journal of the Canadian Mining Institute*, vol. v. pp. 218–227.

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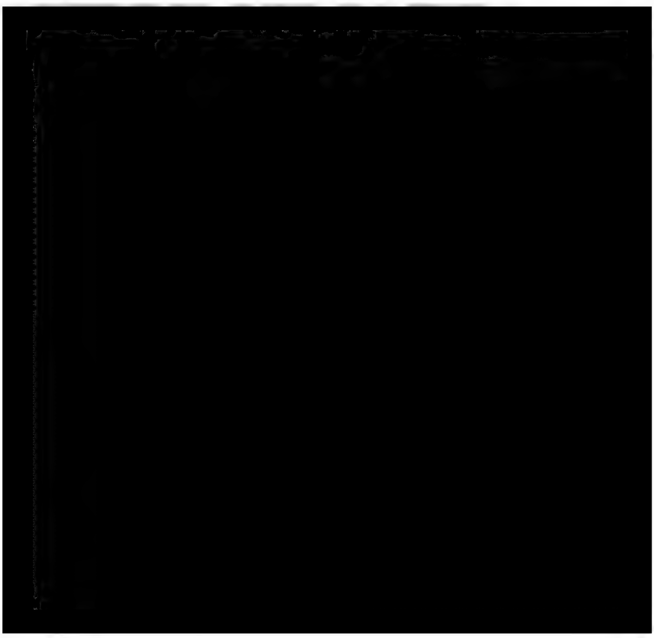
Königshütte in Upper Silesia. This works has consequently been established for a hundred years.* The establishment of this works was of the utmost importance for the present Prussian and German iron industry. It crowned the efforts of Frederick the Great to establish an iron industry. Before 1790 the charcoal furnaces of Upper Silesia had already experienced a want of charcoal, with the result that the Mining Department began to consider seriously the question of charcoal furnaces, and one was subsequently erected near Gleiwitz and successfully put into operation. This employed water power, and as soon as it was found to be a success a decree was published by Frederick William III. on November 15, 1797, authorising the preliminary consideration of plans for a larger works to be provided with steam power, and a subsequent decree of February 15, 1799, authorised the immediate erection of such a works, to be provided with two blast-furnaces, and it was further decreed that this works should be called the Königshütte. The two furnaces were each 40 feet high by 11 feet 4 inches in width at the bosh, and they were provided with two steam engines capable of providing for each blast-furnace 2400 cubic feet of air per minute at a pressure of from 2·75 to 3 lbs. per square inch. Now the works possesses 266 steam engines having a total of 21,833 horse-power, while the number of employés amounts to 6466. The rise and progress of the works are outlined in some detail.

II.—*CHEMICAL COMPOSITION OF PIG IRON.*

Sampling Pig Iron.—At a conference of chemists attached to Ural ironworks held at Ekaterinburg, it was resolved † that the samples in the case of grey pig iron should be taken right across the fractured pig, but deep drillings at several points might also be accepted. The use of the saw and the file, however, is not acceptable. White pig iron, and such alloys as ferro-manganese, spiegeleisen, silico-spiegel, ferro-silicon, ferro-chrome, &c., must be broken down fine and passed through a very fine sieve. Sampling molten pig iron was not considered a satisfactory method.

* *Stahl und Eisen*, vol. xxii. pp. 1029-1032.
† *Ibid.*, p. 443.



	Carbon.	Manganese.	Silicon.	Phosphorus.	Iron.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Foundry pig iron	4·0	0·7	2·0 to 3·0	0·10 to 1·7	91 to 93
Bessemer pig iron	3·5	0·5 to 1·0	0·6 ,, 2·5	0·06 ,, 0·1	93 ,, 95
Basic pig iron	3·5	1·1 ,, 2·0	0·2 ,, 0·5	1·90 ,, 2·7	91 ,, 93
Forge pig iron	3·5	0·2 ,, 1·0	0·5	0·30 ,, 1·7	93 ,, 95
Steel iron	3·5	2 ,, 5	0·2 to 0·5	0·1	91 ,, 94
Spiegeleisen	4 to 5	5 ,, 12	0·1	0·1	83 ,, 91
Ferro-silicon	1·5	2·0	10 to 12	0·1	84 ,, 86

Charcoal Pig Iron.—In an account of charcoal manufacture in Ontario, W. L. Goodwin * refers to the history and present condition of charcoal iron manufacture in that colony. The following analyses of Deseronto charcoal iron are given :—

	Per Cent.	Per Cent.	Per Cent.
Iron	94·59	94·07	95·30
Silicon	1·56	1·82	0·734
Sulphur	0·01	0·007	0·01
Phosphorus	0·12	0·17	0·18
Manganese	0·338	0·327	0·318
Graphitic carbon	1·88	2·053	3·425
Combined carbon	1·23	0·957	

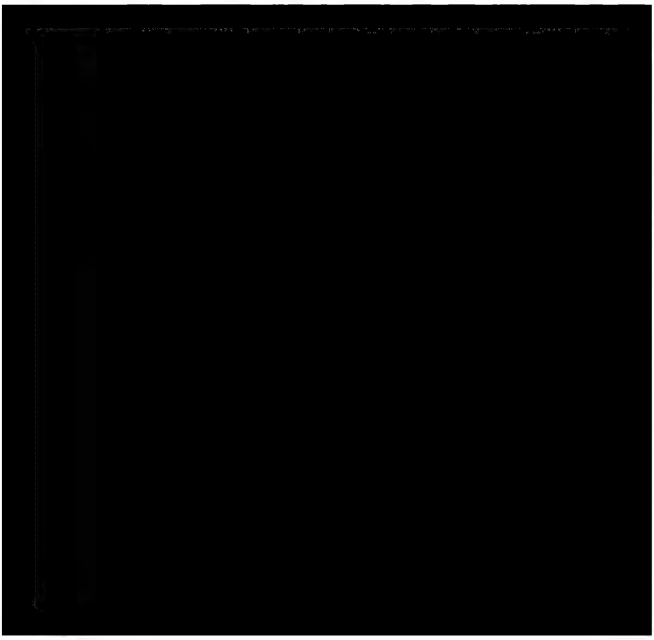
An analysis of mixed retort and kiln charcoal shows 0·011 per cent. of phosphorus.

III.—*BLAST-FURNACE SLAGS.*

The Constitution of Slags.—H. E. Ashley † studies slag constitution by means of the triaxial diagram, but makes another departure in its form, as use is made of a right-angled isosceles triangle, so as to obtain rectangular co-ordinates for two of the factors. The data are largely taken from H. O. Hofman's paper on the temperatures at which certain ferrous and calcium silicates are formed in fusion, and it is shown that the data given, when replotted in this way, give, in a much more comprehensible fashion, the properties of the silicates investigated. The ternary mixtures of lime and silica respectively with ferrous oxide, alumina, and magnesia are investigated in this way. The relation between the mineralogical investigation of solid slags and the thermal examination of molten slags is also discussed, and it is held that their composition is not identical.

* *Journal of the Society of Chemical Industry*, vol. xxi. pp. 743–746.

† *Transactions of the American Institute of Mining Engineers*, Mexico meeting, 1901.



of working affect the product. As an example, the effect of a change in the nature of the coke used is given. The author then deals with the elimination or increase of sulphur, silicon, phosphorus, manganese, and carbon. The latter element is sometimes increased and sometimes decreased, and many generalisations by one authority are stoutly contradicted by another, though, as a matter of fact, both are based on the particular conditions of particular experiments. A small percentage of fuel, high blast, high carbon, and high silicon tend to cause iron to lose carbon, and *vice versa*. Requirements for varied conditions of working are then dealt with, and finally the author advocates low tuyeres and two spouts on the cupola, so that the iron need not accumulate and rise to the tuyeres when the ladles are being changed.

Further discussion has ensued on the subject of the melting ratio in the cupola, and a large number of opinions have been collected. The figures given seldom exceed 10 lbs. of iron to 1 of coke. In one instance as much as 15 or 16 to 1 is given, but that is exceptional. A more general ratio is 9 to 1, or even 8 to 1, and sometimes it is as low as 5 to 1.*

R. Beneke † discusses the suggestion that, if any improvements with a view to saving fuel are made in cupola practice, these must lie in heating the cupola blast by the waste heat from the cupola itself. The author questions whether this would be any improvement at all, quoting a calculation by Ledebur. There is something to be said in favour of hot blast and something against, but it is not easy to say exactly which is the more justified, though the author favours the adverse view. It is not merely the temperature of the blast which plays an important part in cupola practice, but also its quantity, and the way it is admitted into the cupola and divides itself in the cupola interior. The author instances his experience in connection with chilled castings at the Humboldt works. Here, from quite similar raw materials, furnace lining, and blast pressure, he has found repeatedly that the hard layer of the finished product is thicker when the metal has come from a narrow cupola than it is when a wider cupola is employed. The only explanation the author can find for this is that the ratios between the cross-section of the tuyere orifices to that of the cross-section of the cupolas varied, and that in the narrow cupola the blast penetrated farther towards the middle than it did in the wider cupola.

* *Journal of the American Foundrymen's Association*, vol. xi. Part II. pp. 71-76.
† *Stahl und Eisen*, vol. xxii. pp. 610-613.

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cupola, the author states, are the Whiting and the Colliau, the difference lying in the arrangement of the tuyeres. The fore-hearth is not in use. The author then proceeds to deal generally with the question of the pressure of blast to be used in cupolas, and next discusses the question as to possible saving in coke consumption. Means to this end lie in heating the blast, more complete combustion of the carbon, and utilisation of the available heat from the cupola gases. The fore-hearth, he thinks, will not form a part of new foundry plants; and, dealing with the question of mixers, he observes that desulphurisation and proper mixing can be well effected in large-sized ladles, in which the metal can be left for a long time, and in which it will undergo frequent shaking in its transit to the moulds. Lochner, the manager of the foundry at the Gutehoffnungshütte, has made a special study, the author observes, of the advantage of such prolonged standing before pouring. From an American source the author quotes a case in which such molten iron was allowed to stand for 120 hours under a slag cover without disadvantage. The question of loss of metal is one that receives frequently too little attention. As a rule, this is estimated to be from 6 to 8 per cent. of the weight of the metal charged into the cupola, but the American Foundrymen's Association have collected statistics which show that in 70 cases the lowest loss was 2 per cent. and the maximum as much as 13·6. Really, the actual loss of weight in the cupola should be only from 1 to 1·5 per cent. of the weight of the metal charged, due to the oxidation and passage into the slag of some 0·35 per cent. silicon, 0·3 per cent. manganese, and some 0·3 to 0·5 per cent. iron. The remaining loss is of mechanical origin, and may be very largely recovered by treatment of the waste products. It is the care or absence of care given to this that leads to the great variation in the figures quoted. The metal recovered is, it is true, of poorer quality. It contains much sulphur and manganese, but little silicon, and possibly but little carbon. Still, it has its market value, and is best added to the open-hearth charge. How great, indeed, is the saving when the loss is reduced in this way from 6 to 8 per cent. to from 2 to 4 is very easy to calculate. The methods of recovery, both magnetic and mechanical, are briefly referred to.

Dealing next with the charge smelted and its alteration in the cupola, the author observes that the cupola fusion means: (1) with normal manganese contents, a loss of about 15 per cent. of the silicon; (2) with the normal manganese contents of about 0·8 to 1·0 per cent.,

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used sand to a sifting or cleaning apparatus to recover clean material. The use of sand blast in tumbling barrels is also mentioned.

Calculating the Weight of Castings.—C. M. Schwerin * gives a method for the calculation of the weight of castings with the aid of the planimeter. An accurate drawing of the pattern is employed, as that gives a closer result than a drawing of the finished work on account of compensating errors.

Malleable Castings.—Some notes are given † on the use of sal-ammoniac in the manufacture of malleable castings. It is generally used to rust the packing used in the boxes, and for castings which are to be very strong and tough. When non-metallic packing or no packing at all is employed, the sal-ammoniac is not added. About 10 lbs. of the salt and 25 gallons of water are used to 8 or 10 tons of packing.

J. V. Woodworth ‡ describes the manufacture of malleable cast iron in America.

Foundry Economy.—Foundry economy is dealt with by P. R. Ramp,§ shop conditions by H. McPhee,‖ accounts by J. G. Stewart.¶

D. Reid ** describes some methods of increasing foundry production. Amongst other matters, double shifts and the subdivision of labour are dealt with.

R. C. Cunningham †† also discusses foundry costs and labour-saving systems. Methods of recording and interpreting foundry costs are further dealt with in a note by P. Longmuir. ‡‡

The Valuation of Pig Iron.—R. Moldenke §§ proposes a method for the proper valuation of pig iron for foundry purposes, and the work is to be undertaken by the American Foundrymen's Association. All

* *Transactions of the American Institute of Mining Engineers*, February and May, 1902.

† *Engineer*, vol. xciii. p. 521.

‡ *American Machinist*, vol. xxv. pp. 1014-1017.

§ *Journal of the American Foundrymen's Association*, vol. xi. Part I. pp. 39-42.

‖ *Ibid.*, pp. 15-16.

¶ *Ibid.*, pp. 77-92.

** *Ibid.*, pp. 29-33.

†† *Ibid.*, pp. 43-47.

‡‡ *Engineering Magazine*, vol. xxiii. pp. 887-894.

§§ *Iron Age*, June 26, 1902, pp. 25-27.

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The British Association of Waterworks Engineers recently appointed a committee to report on the desirability and feasibility of adopting some satisfactory basis for standardisation of cast-iron pipes, and the amount of support likely to be secured in the event of the matter being put into practical shape. With this object in view a circular was distributed and replies elicited from 119 waterworks engineers and pipe-founders. Only two expressed unqualified disapproval.*

* *Iron and Coal Trades Review*, vol. lxv. pp. 278-279.

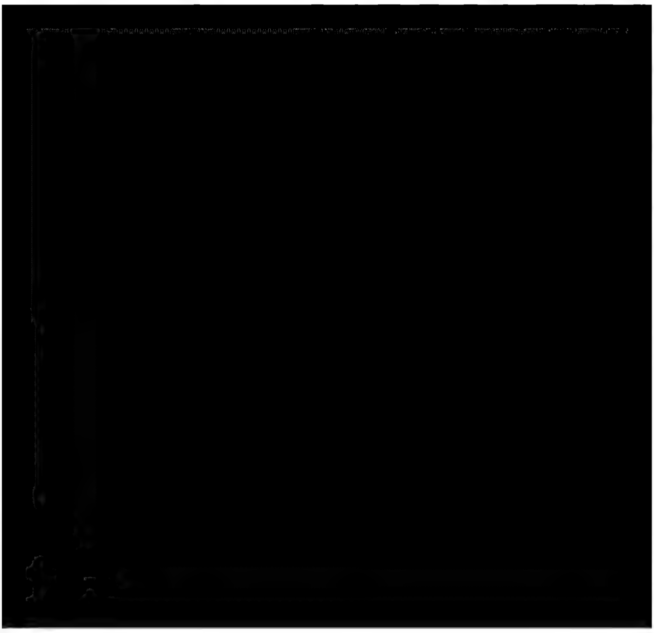
as it rolls from end to end through the central hottest portion of the hearth. The mass of iron is then about as long as the furnace is wide, and is about 3 feet wide and 24 to 30 inches high. The end door is now opened and the mass is shot into the squeezer, which is of special form, with hydraulic rams acting through pressing plates to squeeze the bloom laterally, endways and vertically. The pressing plates are sectional, so as to form spaces for egress of the cinder, and the top cylinder is furnished with an intensifier which increases the final pressure to 1800 tons on the top area of the bloom. The finished dimensions are 54 inches in length and 24 inches in width, the thickness varying according to the weight. The squeezing machine is movable, and is intended to be run in front of each furnace as soon as it is ready for discharge. Good results are usually obtained with this machine. The pig iron used varies between—

S.	P.	Si.
0·03	0·50	0·60
0·26	1·35	1·40

The normal cinder contains 0·30 sulphur, 1·73 phosphorus, and 20 per cent. of silica. About 500 lbs. is used per ton of iron charged, and 350 to 550 lbs. of scale. The average duration of a heat is forty-eight minutes, but it is believed that this will be reduced to forty minutes for a 4000-lb. charge. On the average the weight of rolled slab is about equal to the pig iron charged, and the loss in finished plate is 5 to 6 per cent. as compared with 16 per cent. in ordinary puddling. It is confidently believed that slabs and billets will be produced at a cost not exceeding that of ordinary steel.

Direct Reduction of Iron.—H. Leobner * publishes details of a series of experiments carried out some years ago at an ironworks in Lower Austria in the attempt to find an economical method for the direct production of iron. The process tried was similar to and was partly based upon a careful study of Särnström's direct process, published in 1882, and also of C. Husgavel's experiments five years later, with an improved bloomary furnace, the aim being to produce economically malleable iron in the form of a bloom of such quality that it could be used for the regular manufacture of ordinary articles of commerce. The furnace employed somewhat resembled a small blast-furnace, with a separate chamber or retort attached, into which the

* *Berg- und Hüttenmännisches Jahrbuch der k. k. Bergakademien zu Leoben*, vol. l. pp. 1-18.



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Electric Smelting of Iron Ore.—J. B. C. Kershaw * states that ferro-chrome is made electrically at one works in the United States and at one in France. In Germany it is made by the Goldschmidt process. Ferro-silicon is made electrolytically in France, and ferro-titanium in America. Reference is also made to the Italian experiments in the direct process of producing iron and steel by electric smelting.

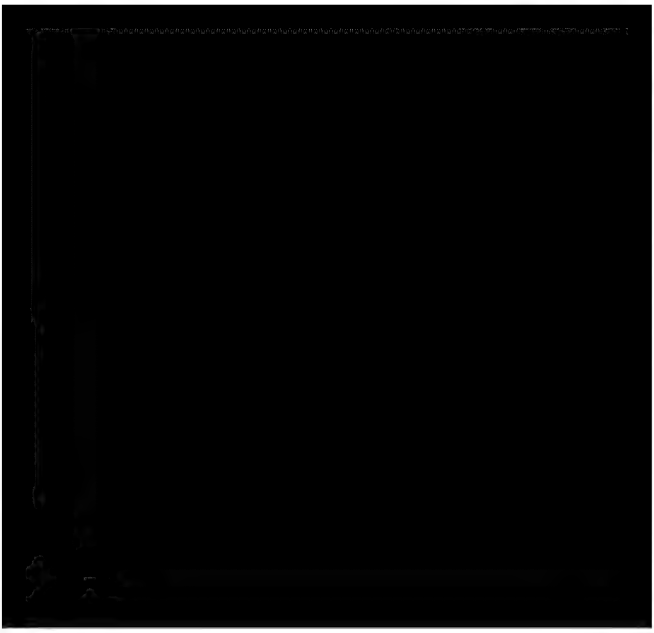
H. Harmet † describes his direct process in which heated ore and coke are forced into the top of a vertical shaft, at the bottom of which the electrodes are placed for reducing the ore.

Native Method of Iron Reduction.—R. G. Cumming ‡ describes the method of reducing iron from its ores which he found in use among the Bakatlas, a tribe of Bechuanas, about the year 1843. He observes that they worked a great deal in iron, manufacturing various articles with which they supplied the neighbouring tribes. The ore was obtained by "excavating in the surrounding mountains," and was smelted in crucibles, a great deal of the metal being wasted, and only the "best and purest" being preserved. They employed a sort of double bellows, consisting of two bags of skin, by which the air was forced through the long tapering tubes of the two horns of the oryx. The person using the bellows sat between the two bags, which he raised and depressed alternately, working one with each hand. Their hammer and anvil consisted of two stones, but they made spears, battle-axes, knives, assegais, sewing-needles, &c., the workmanship being neat.

* *The Mineral Industry*, vol. x. pp. 256-257.

† *Comptes Rendus Mensuels de la Société de l'Industrie Minérale*, 1902, pp. 85-86; *Electro-Chemist and Metallurgist*, vol. ii. pp. 93 95.

‡ *Five Years' Hunting Adventures in South Africa*, p. 59. Popular Edition: Edinburgh, 1902.



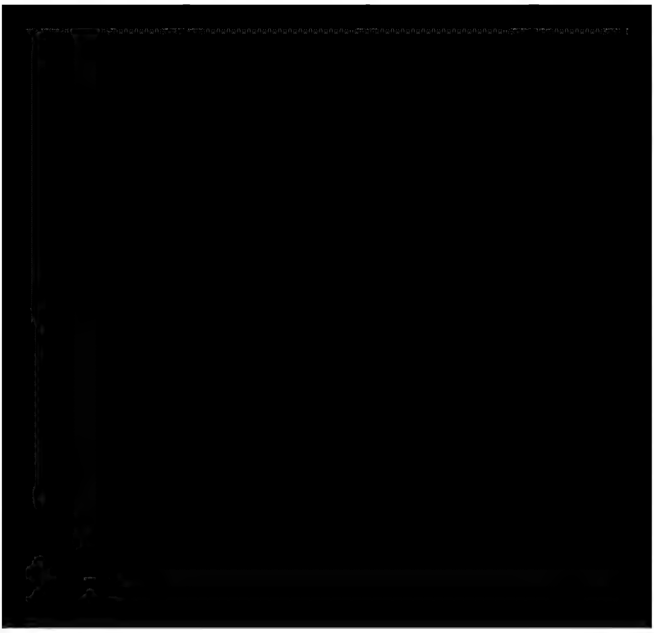
&c., without the intermediate ingot stage, but he does not see any possibilities for the future in this method.

Rolling Girders with Wide Flanges.—R. Cramer * gives a description, accompanied by illustrations, of the Grey universal rolling mill at Differdingen. The ingots are first rolled down in an ordinary roughing train to a length of about 15 to 20 feet, and are then carried forward to the universal mill. This consists of two stands, the first of which contains one pair of horizontal rolls. In these only the edges of the flanges are rolled and the width of the flange is thus determined. The second stand has one pair of horizontal rolls and one pair of vertical rolls, and by this combination the main rolling operation is effected of working the surfaces of the flanges and finishing both flanges and web down to their proper thickness. The girder is guided through the rolls by laterally adjustable guide bars, and is supported beneath on guide rollers. It is never lifted or turned, but passes direct backwards and forwards until finished, consequently very little straightening is necessary. The weight of a set of rolls for a given girder section is scarcely more than one-third that of a set of ordinary rolls. The horizontal rolls of both stands must of course be changed to suit the depth of the section, but the vertical rolls which work the outer surfaces of the flanges are wide enough for all sections, and therefore never require to be changed.

Rolling-Mill Engines.—Some illustrations are given † of a rolling-mill engine built by G. Sellers for the Wardsend steelworks at Sheffield. It is a cross compound engine with 26 and 40-inch by 60-inch cylinders. The rope fly-wheel is 27 feet in diameter, and drives a 12¼-foot pulley, centred 74½ feet distant, to drive cogging and wire mills. When new boilers carrying 160 lbs. steam pressure were built, a third cylinder was added for triple expansion; but, owing to the increase of the work done, this has been disconnected, and the engine is worked compound again at the higher pressure. With triple expansion, 10 lbs. of steam per horse-power hour was used.

Illustrations, with many detail sections, are given ‡ to show a new rolling-mill engine built by the Filer & Stowell Company for the Republic Iron and Steel Company at Youngstown. It is of the Corliss cross compound type, with cylinders 44 and 82 inches in

* *Zeitschrift des Vereines deutscher Ingenieure*, vol. xlvi. pp. 1221-1223.
† *Engineer*, vol. xciii. pp. 438-439.
‡ *Engineering News*, vol. xlviii. pp. 138-143.



to 9 square inches. For this purpose a special design was used. The fixed and movable shear blades are carried by a frame trunnioned at its base, and the upper shear blade is pulled down as the frame moves over by eccentrically pivoted links. The motion is produced by a hydraulic steam intensifier with a stroke of 24 inches. The upper blade is pivoted so that the incoming billet pushes it out of the way on the return stroke. The valve gear is operated by the billet striking a trigger 30 feet in front of the shears, more or less, according to the length desired.

Shears are also described for cutting hoop iron as it issues from the mill. The knives are mounted on two small conical drums, which are geared together. The upper one is carried in a hinged frame, which is raised and lowered at the desired intervals by change gear so as to bring the knives together to cut off the requisite length.

Modern Rolling Mills.—H. Brauns * describes and illustrates the new rolling-mill plant of the Dortmund Union works. The space available was but small, and considerable care was therefore necessary in planning it. A two-high reversing mill was decided on. Beams up to 23·6 inches high and L iron of half that height were required to be rolled, and in order to obtain the maximum output at as low as possible a cost, it was assumed from the commencement that it would be necessary to roll, at one heat to the semi-finished state, ingots from the steelworks weighing not less than 3 metric tons, and after treatment in an unheated soaking pit. For other ingots heated soaking pits were also constructed. The actual arrangements adopted are well shown by the aid of numerous illustrations and a plan showing the general arrangement of the plant. Very considerable use is made of electric power for motor purposes, and steam power derived from ten Babcock & Wilcox boilers is also available. The plant was put into operation in July 1901.

W. Schnell † publishes an account and drawings of a rolling mill erected in 1901 by the Röchling iron and steelworks at Völklingen-on-the-Saar. It serves to roll down ingots of some 4 tons in weight, and with a maximum cross section of 21·7 by 16·9 inches. The ingots are raised by electric travelling cranes from the soaking pits and delivered to the rollers by an hydraulic arrangement. There are

* *Stahl und Eisen*, vol. xxii. pp. 591–604, with one plan and fourteen illustrations in the text.

† *Ibid.*, pp. 413–414, with three sheets of drawings.

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as also the rolling of rails and the construction of steam engines and steamships. In 1810 a company was formed to amalgamate the three ironworks—the Gutehoffnungshütte, the St. Antonihütte, and that of Hammer-Neu-Essen. The St. Antonihütte was erected as far back as the middle of the eighteenth century, while the old Gutehoffnungshütte at Sterkrade was founded in 1781. The Hammer-Neu-Essen works belonged originally to the grandmother of F. Krupp, and was sold by her in 1808 to H. Huyssen of Essen. This company was finally reorganised under its present name in 1873. The present company mines its own raw materials, and may generally be considered, it is stated, as perhaps the best arranged of all the large iron and steelworks. The Sterkrade section of the works includes large machine and boiler shops, and a steel foundry which is capable of making castings up to 60 tons in weight. Very many large bridges have been made at this part of the works, including six over the Rhine and three over the Elbe. At the Oberhausen portion of the plant are nine large blast-furnaces, making 400,000 tons of pig iron per annum, and 451 coke ovens. At Oberhausen and Neu-Oberhausen are also very large steelworks and rolling mills. The old Hammer-Neu-Essen ironworks has been converted into a works for the manufacture of fire-resisting materials. Altogether the various works give employment to 14,000 workpeople and officials, and are equipped with engines of 46,000 horse-power.

An account of the works of the Gutehoffnungshütte at Oberhausen and at Sterkrade has been published by F. Frölich.*

An armour-plate rolling mill is in process of construction for the Ischora works of the Russian Admiralty at St. Petersburg, the work having been entrusted to the firm of Klein Brothers of Dahlbruck, in Germany.† It is to be driven by a horizontal twin reversing engine, the cylinders of which are 56 inches diameter, with a stroke of 5 feet. The diameter of the rolls is 47½ inches, the length being 13 feet 1 inch. The mill is intended to deal with armour plates up to 50 tons in weight. The conditions of the contract stipulate that the whole of the material used in the construction shall be of Russian manufacture, and the firm are consequently building the machinery at their branch establishment at Riga.

F. Frölich,‡ in describing the metallurgical section of the Düsseldorf

* *Zeitschrift des Vereines deutscher Ingenieure*, vol. xlvi. pp. 1021–1031, 1177–1182.
† *Ibid.*, pp. 1129–1130.
‡ *Ibid.*, pp. 1413–1421.

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wages, and the excellence of the mechanical appliances are commented upon, though it is remarked that three-cylinder engines are not adopted. The main difference is in the speed of the rolls, reduction gear being generally absent and the speed being on the average double that in England, and heavy draught is put on to bring the work down rapidly while hot. The latest practice is to edge the plates in separate vertical rolls driven by an independent engine. Compound condensing engines, with Corliss or similar valve gear, are in common use. Horizontal furnaces with power-worked doors are the rule for re-heating slabs. Gas-fired regenerative heating furnaces are universal, and the author animadverts strongly on the retention of coal firing. American mills are 2 or 3 feet higher than is customary elsewhere, so that the ingot does not have to be lowered from the furnaces, and all the machinery is more accessible. Very careful records are kept, and lost time is thus reduced. Hydraulic transmission of power is being generally replaced by electricity at 250 volts. A special feature of American practice is the endeavour to keep all the parts of the mill at work, so that one set of rolls is never idle while the other is occupied. The value of standardisation also is mentioned.

The new blast-furnaces, Bessemer and open-hearth steel plant and rolling mills of the Minnequa works, Pueblo, Colorado, are described,* with the aid of plans and other illustrations. The Bessemer plant includes rail mills, blooming mills, soaking pits, hot saws, and a cold finishing department. The open-hearth plant supplies a 40-inch blooming mill, bar mills, 12 and 14-inch merchant mills, bar and hoop mills, and a Garrett rod mill. There is also a wire plant, and of each of these a short account is given to supplement the account of the blast-furnaces and steel plant.

Electric Power in the Rolling Mill.—S. S. Wales † mentions the use of the electromotor in the rolling mill for overhead cranes, charging machines, roller tables, screwing gear for rolls, and other purposes. Motors for mill use may be of any or every type built, but in any case it is probable that no single type would cover the ground satisfactorily under all conditions. At the present time no motor has had such diversified application in this line as the tramway series motor; its claim for recognition being the powerful starting effort, its

* *Iron Age*, August 14, 1902, pp. 1-11.

† *Proceedings of the Engineers' Society of Western Pennsylvania*, vol. xviii. pp. 142-153.

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C. Dantin * describes the electric plant at the Parkgate steelworks.

A. Abraham † discusses the use of electricity in ironworks. Illustrations are given of electric cranes and transport appliances at the Friedenshütte, the steelworks at Antwerp, and the Cockerill works at Seraing. The rolling mills and live-roller tables of the Parkgate works and of the Friedenshütte are also described.

At the Nyteroppa ironworks in Värmland, Sweden, electric transmission of power has been successfully applied to the rolling mills.‡

The electric transmission of power at ironworks is discussed by C. Machacek.§ The direct current is found to be better adapted to the requirements of metallurgical works than the alternating current.

Illustrations are given ‖ of the electric installation at the Antwerp steelworks. These include plans and elevations of the electric cranes used for working the soaking pits, and photographic illustrations of the motors which drive some of the rolling mills. One of these motors of 325 horse-power capacity is coupled by belt to a 24-inch two-stand blooming mill, which runs at a speed of 70 revolutions per minute, and has a fly-wheel of about 30 tons weight. In one stand 880-lb. billets are reduced from 10 inches square to $3\frac{1}{4}$ inches square; in the other stand 450-lb. billets are rolled from $7\frac{1}{4}$ inches square to $2\frac{3}{4}$ inches square section. Behind the blooming mill are two finishing mills, the object being to supply each from one stand of the blooming mill. These mills are direct-driven by electric motors. The larger one, a 14-inch five-stand mill, is driven by a 450 horse-power motor, whilst the other, a $10\frac{1}{2}$-inch five-stand mill, receives its power from a 325 horse-power motor.

A number of illustrations are given ¶ of the electric power installation at the Ougrée works, Belgium. Altogether there are 64 motors, ranging from $\frac{1}{2}$ to 70 horse-power, used for driving cranes, hoists, live rollers, &c. Other illustrations are given ** of the electric installation at the Upper Forest and Worcester steel and tinplate works.

Stripping Ingots.—The evolution of the ingot-stripper is traced by A. E. Fay,†† and eight illustrations are given to show some of the

* *Génie Civil*, vol. xli. pp. 268-271.

† *Ibid.*, pp. 277-282.

‡ *Affärsvärlden*, vol. ii. p. 650.

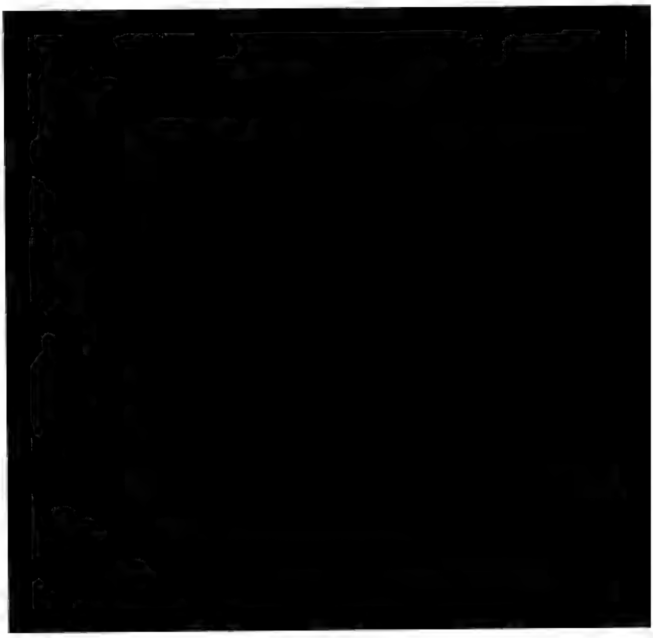
§ *Berg- und Hüttenmännisches Jahrbuch der k. k. Bergakademien*, vol. l. pp. 149-172.

‖ *Iron and Coal Trades Review*, vol. lxiv. pp. 1321-1323.

¶ *Ibid.*, pp. 1200-1202.

** *Ibid.*, p. 1263.

†† *Iron Trade Review*, May 1, 1902, pp. 64-67.



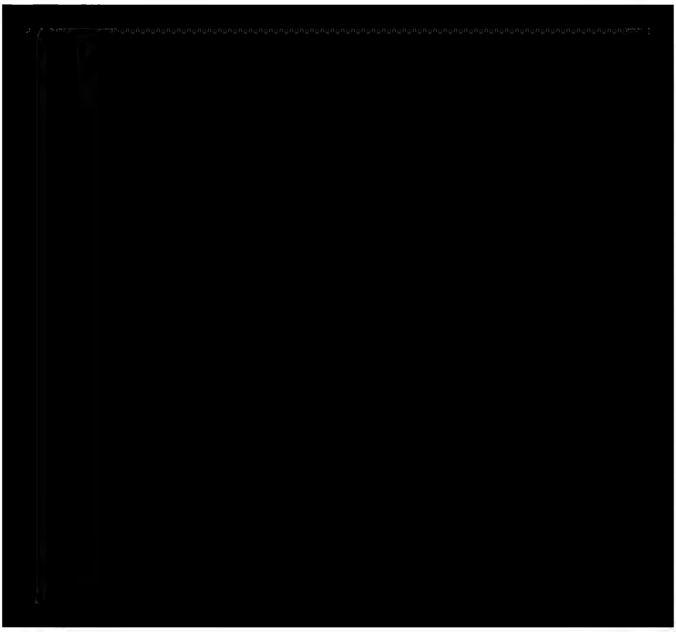
PRODUCTION OF STEEL.

CONTENTS.

I.—*THE CARBURISATION OF MALLEABLE IRON.*

The Manufacture of Electro-Steel.—In a paper read before the Swedish Association of Ironmasters, F. A. Kjellin * showed that in Sweden excellent results have been obtained. Where ample water power is available, the process should have a considerable future. The idea of making steel by electricity is not new. In 1879 Sir William Siemens, then President of the Iron and Steel Institute, constructed an electric furnace for steel, but the method was found to be too costly for practical use. In 1899 the author proposed that an electric steel furnace should be built at Gysinge without electrodes. At the end of February 1900 the first furnace of this kind was built, and the first casting was made on March 18, the steel being found to be of excellent quality. The problem was thus solved technically, but not commercially, for with the 78-kilowatt dynamo employed only 575 lbs. of steel was made in twenty-four hours, and the furnace only held 160 lbs. A larger furnace was built in November 1900, and made 1200 to 1400 lbs. of steel per twenty-four hours. In the summer of 1901 new steelworks were built, with a 300 horse-power turbine. The new furnace has a capacity of 3600 lbs., and the production is calculated at 1500 tons annually if charged with cold material. The steel made is of superior quality, and shows less tendency to crack when hardened than ordinary steels. Its freedom

* *Jernkontorets Annaler*, vol. lvii. pp. 289-296.



Crucible steel, containing 1·3 to 1·5 per cent. of carbon, is poured on both sides simultaneously, and when the ingot is set it should be allowed to cool gradually to avoid cracking. For further working, the ingots are heated slowly, and not to too high a temperature, for cogging and finishing into plates in rolling mills. The material is not allowed to cool, but requires further reheating between cogging and finishing, and the plates are then marked out as soon as possible and heated on coke fires before shearing into shape. An analysis shows:—

C.	Mn.	Si.	P.	S.
1·30 to 1·50	0·35 to 0·45	0·20	0·04 to 0·06	0·02

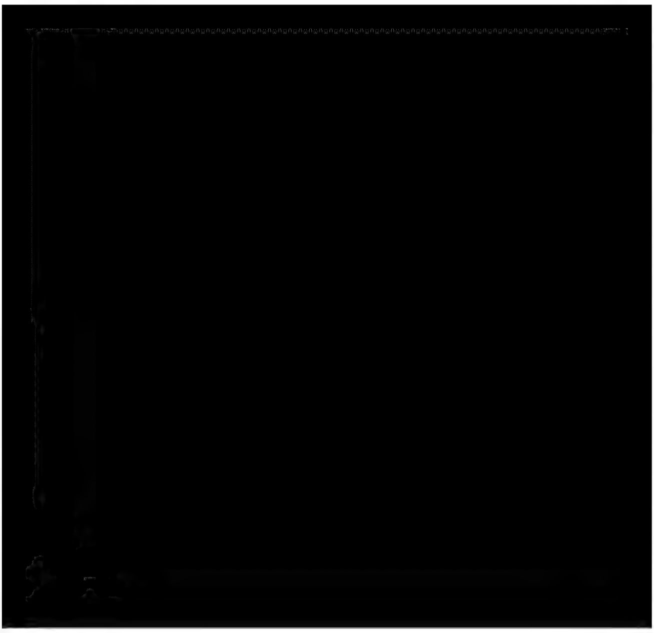
II.—*THE OPEN-HEARTH PROCESS.*

Open-Hearth Steel Processes.—J. Christie * reviews the modern developments of the open-hearth steel process. After a reference to the method of adding metal from the converter, which is not considered satisfactory, the direct process, with metal from the blast-furnace with ore additions, is mentioned, and then the Bertrand-Thiel, Talbot and Monell processes are described.

Open-Hearth Steel in the Siegerland.—The production of open-hearth steel in the Siegerland forms the subject of a paper by Münker.† The mild steel of this district is not characterised by any special qualities as the pig and wrought iron are, and it was due to the excellent properties of the latter product that the introduction of the open-hearth process in the district was so long delayed. There are now four Siemens-Martin steelworks in operation, comprising a total of thirteen open-hearth furnaces, the capacity ranging from 12 to 25 tons. All of them are basic-lined, notwithstanding that it would be easy to manufacture from the Siegerland ores a non-phosphoric pig well suited for acid working. But, owing to the trouble of selecting a scrap of sufficient purity, the basic process is preferred. The annual production of open-hearth steel in these works is about 170,000 tons, most of which is worked up in the rolling mills of the same district.

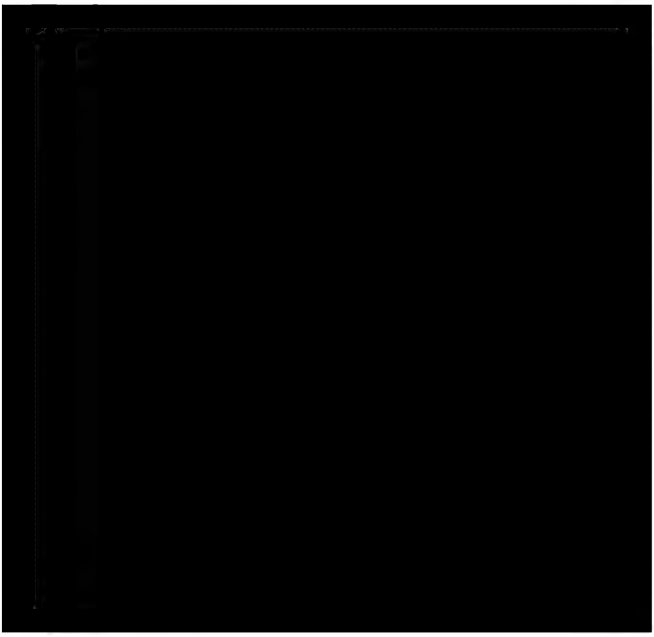
* Paper read before the Engineers' Club of Philadelphia; *Iron Age*, August 7, 1902 pp. 21–23.

† *Zeitschrift des Vereines deutscher Ingenieure*, vol. xlvi. pp. 1049–1050.



readily run out of the building. The ingots are placed hot in the soaking pits. The old-fashioned revolving hydraulic casting crane has been replaced by electric travelling cranes; the ingots can be cast anywhere, and the furnace immediately put into repair after tapping without the workpeople being subjected to great heat. Direct metal is now often employed. The author points out the advantages and disadvantages connected with having the whole plant of a works on one level, and thinks the former outweigh the latter. At the Homestead steelworks there are three open-hearth plants, built at different dates. The oldest has eight 25 to 30-ton furnaces placed in two parallel rows. The second plant has also two rows of furnaces, but these number sixteen and they are of from 40 to 50 tons capacity. This plant is provided with an armour-plate mill. The most recent and most important of the three plants was commenced in 1897. It comprises twenty-four 50-ton furnaces, and, making sixteen heats per week per furnace, has a yearly output of about 900,000 tons. All this is rolled at the works itself. Each furnace has its own stack. They are heated by natural gas, and are charged by machines built by the Wellman Seaver Engineering Company. These have each a capacity of about 2 tons per minute. Shortly after this plant was completed the Carnegie Company commenced the erection of the Duquesne open-hearth plant. It consists of twelve 50-ton furnaces placed in one row, but it differs from the Homestead works by having the level of the charging floor some 9 feet above that of the works generally. The furnace is constructed on a massive foundation, and consists of a layer of firebricks, then one of chrome iron ore, and next of magnesite bricks. On this follows loose magnesite, which is burnt in. Each furnace has three water-cooled charging doors and two smaller doors for repairs at the charging side, while at the other side are two large and two small doors and the tap-hole. A slag pit lies in front of each furnace.

The plant of the Pennsylvania Steel Company was erected in 1900. It consists of six 50-ton tipping furnaces placed in two rows, with a common pit, and all served by a 50-ton travelling casting crane of electric-hydraulic type. The furnace is charged with about 80 per cent. of molten pig iron taken direct from the blast-furnaces and scrap. The latter is charged in rectangular sheet boxes. At the Pencoyd works, which is next described, are nine 30-ton open-hearths and one 75-ton Talbot furnace, which was put into work in 1899. This furnace the author describes and illustrates. Other plants described or referred to include those of the Sharon Steel Company, with eight 50-ton open-



peat, costing about 75 cents per cubic yard delivered at Motala. Two large gas-producers are used, from which the gas is led to the open-hearth furnaces through a condenser for ridding it of some of its moisture. Although the peat gas, owing to the distance the peat has to be brought, is dearer than coal gas, it is used preferably in most Swedish steelworks in consequence of the insignificant amount of sulphur and phosphorus it contains. In the rolling mills there is a smaller peat gas-producer for one of the plate furnaces, and thin steel plates especially scale less in rolling when the furnace is fired with peat gas.

III.—*THE BESSEMER PROCESS.*

The Theory of the Bessemer Process.—In a paper read at the general meeting of the Verein deutscher Chemiker, F. Fischer* discusses the theory of the Bessemer process, considering in particular a former paper on this subject by H. Ponthière.† The latter took as his basis a white pig iron of the following composition :—

Iron.	Silicon.	Manganese.	Carbon.	Phosphorus.	Sulphur.
92·52	1·00	1·50	3·50	1·40	0·01

and he grouped these elements together in the following way, considering the pig iron to have the composition :—

	Per Cent.
Manganese carbide, MnC_2	1·40
Manganese silicide, Mn_7Si_2	0·64
Manganese phosphide	trace
Manganese sulphide	trace
Iron carbide, Fe_3C	46·50
Iron silicide, FeSi	2·58
Iron phosphide, Fe_3P	8·98
Iron sulphide	trace
Iron, free	39·90
Total	100·00

These compounds Ponthière employed in his subsequent thermochemical calculations, though he left out of consideration the heats of formation of iron silicide and iron carbide, while calculating those for iron phosphide and the manganese compounds. According to

* *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. l. pp. 433–436.

† *Journal of the Iron and Steel Institute*, 1897, No. II., p. 96; *Zeitschrift des Vereines deutscher Ingenieure*, vol. xlvi. pp. 1006–1008.

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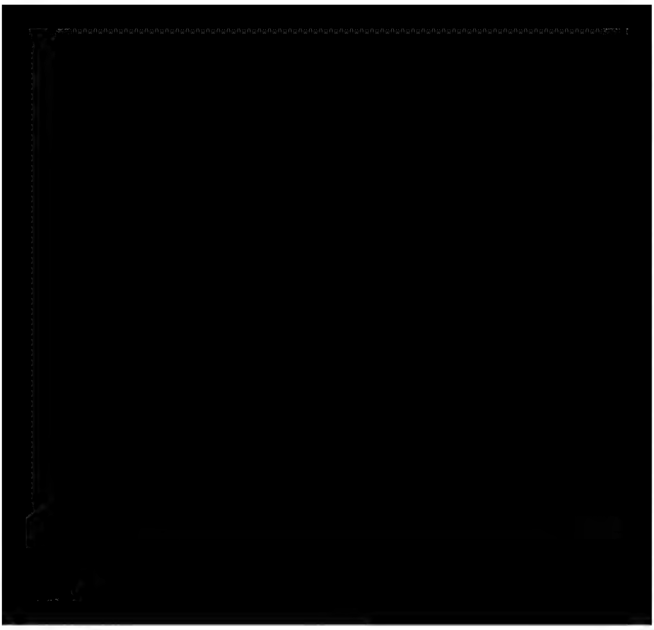
$2CO - 388$ h.w.,* so that 12 kilogrammes of carbon combine with 44 kilogrammes of carbon dioxide with the absorption of 388 h.w. This action of the carbon consequently sensibly cools the metallic bath. Pig iron, when fused with silica or silicates, has been shown to form carbon monoxide and silicon, according to the reaction: $C_2 + SiO_2 = 2CO + Si - 1620$ h.w. This reaction requires, however, such a considerable amount of heat that it probably only takes place at very high temperatures. On the other hand, the reactions: $Si + CO_2 = SiO_2 + C + 1232$ h.w. and $Si + 2CO = SiO_2 + 2C + 1620$ h.w. yield much heat, and are consequently pronounced in their action. Manganese behaves similarly: $Mn + CO_2 = MnO + CO + 268$ h.w.; $2Mn + CO_2 = 2MnO + C + 924$ h.w., and $MnO + SiO_2 = MnSiO_3 +$ about 350 h.w. The combustion of the manganese in carbon dioxide, and its passage into the slag, are therefore also accompanied by a considerable evolution of heat. The following reaction can also very readily take place: $Mn + CO = MnO + C + 656$ h.w. Silicon and manganese do not therefore protect the carbon from combustion, but they reduce again the products of combustion of carbon, and so cause the latter to pass again into the iron. The action of the iron itself is much weaker. At a red heat: (1) $3Fe + 4CO_2 = Fe_3O_4 + 4CO - 81$ h.w.; (2) $Fe_3O_4 + 4CO = 3Fe + 4CO_2 + 81$ h.w., and at a very high temperature (3) $Fe_3O_4 + 8CO = 3Fe + 2C + 6CO_2 - 1071$ h.w. This last reaction is accompanied by such a large absorption of heat that it cannot be very pronounced. Further, $2Fe + 3SiO_2 = 2FeSiO_3 + Si + 104$ h.w. Bell has shown that phosphorus passes into the slag at low temperatures, and is reduced from it again at high ones, but the thermo-reactions connected with the elimination of this element from the iron are still not clearly known. The Bessemer process itself is consequently a mixture of direct combustion with a series of reactions and inter-reactions which are dependent on temperature, time, and mass.

Bessemer Steelworks in Belgium.—V. Firket† describes the improvements lately carried out at the steelworks of Angleur, in Belgium. By the final demolition of all the puddling-furnaces a large space was rendered available for the construction of a new casting pit and shed, in connection with the basic Bessemer plant, to supplement the old circular pit. The new pit is rectilinear, extending away

* 1 technical heat unit calculated for 1 kg. of water = w; 1 hekto unit = 1 h.w. = 100 w.

† *Annales des Mines de Belgique*, vol. vii. pp. 279–304.



Steel Manufacture in America.—The third main division of the report of the British Iron Trade Association * is contributed by Enoch James, and deals with the conditions and recent advances of the steel-works of the States, in respect of processes, plants, and equipment. For this purpose a large number of works were visited, and the report furnishes a valuable insight into the latest American practice. It is divided into three sections, of which the first deals exclusively with the Bessemer process, comparing British and American practice, and describing in lucid detail the American methods of working. The second section is confined to the open-hearth process. Supplementing detailed descriptions of most of the leading plants are some fine illustrations of typical appliances and machinery, including the Wellman charging machine and rolling furnace. In section 3 the author gives his impressions of some of the leading features of American rolling mills, describing the methods adopted in the manufacture of rails, beams, channels, plates, &c., and including photographic views of latest types of machinery.

* "American Industrial Conditions and Competition," London, 1902.

FURTHER TREATMENT OF IRON AND STEEL.

Nickel Steel.—R. S. Tappenden * draws attention to the use of nickel steel for engine forgings, which may be made with tensile strength up to 110,000 lbs., elastic limit 74,400 lbs., and elongation 21 per cent. The low carbon steels will harden readily, and should be annealed to reduce local strains. A nickel steel generally is as easy to forge as high-carbon steels. The cropping of bottom-poured ingots should be 20 per cent. at the top and 5 per cent. at the bottom; from other ingots 25 per cent. should be cut off the top.

New Tool Steels.—Some notes on recent experiments with new tool steels have appeared.† Mention is made of several kinds recently produced in Sheffield, of the experiments made in Germany,‡ of further tests made by J. W. E. Littledale,§ and of recent American experience.

Sergius Kern || has prepared a tool steel having the following composition :—

	Per Cent.
Tungsten	2·00
Molybdenum	0·50
Carbon	0·90
Manganese	0·20
Silicon	0·18

The phosphorus and sulphur must be kept down as low as possible, on the average not more than 0·03 per cent. of the combined elements, out of which not more than 0·01 per cent. should be sulphur. The steel was, and must be, prepared by the crucible process. Such a self-hardening tool steel is very convenient for the machining of hard metals.

* *Iron Age*, July 17, 1902, p. 9.

† *Iron and Coal Trades Review*, vol. lxiv. pp. 1516–1518.

‡ *Journal of the Iron and Steel Institute*, 1902, No. I. p. 600.

§ *Transactions of the North-East Coast Institution of Engineers and Shipbuilders*, vol. xviii. pp. 21–37.

|| *Chemical News*, vol. lxxxv. p. 282.

In a paper read before the Verein zur Beförderung des Gewerbfleisses, Berlin, Sievers * discusses the manufacture of steels for rapid lathe work. He refers to the manufacture of cement and crucible steel as practised at Sheffield, where, as Wedding remarked in the discussion, it is stated that the methods of manufacture are antiquated compared with the great improvements in the method of manufacture at German works, which use gas-heated furnaces. Dannemora iron is chiefly employed at Sheffield in the manufacture of cement steel, the fusion for crucible steel being effected in crucibles free from graphite. According to the views of Seebohm and Dieckstahl, whose method of manufacture the author considers in particular, graphite is objectionable as affecting the uniformity of the distribution of the carbon in the steel, which is made as a rule of 6° of hardness. The carbon content of No. 1 is about 1·5, while that of No. 6 is only 0·75. The various uses to which these steels are put are briefly mentioned. The actual quality of the metal, the author observes, is partly the result of the skill in workmanship employed in its manufacture, and is also due in part to the chemical composition of the metal itself. Chemical analysis does not in itself afford an adequate means of judging the quality of the steel. For instance, it is by no means a matter of no importance whether the manganese that is now always found in lesser or larger quantity in a crucible steel was present in the original metal, or was added to it when fused in the form of spiegeleisen. For best crucible steels only that iron must be used the manganese contents of which are due to the ore used in its manufacture. Passing from this question as to the influence of manganese on crucible steel, the author proceeds to consider that of other elements. These he classifies into two divisions—those whose presence is undesirable, and those whose action is beneficial. The former class includes sulphur, phosphorus, copper, arsenic, and silicon, while the desirable elements, in addition to carbon, comprise manganese, chromium, molybdenum, tungsten, nickel, titanium, and vanadium. With regard to the action of nickel, it is pointed out that its value as an addition in the manufacture of tool steel has not borne out the hopes originally held of its use in this way. Nickel, it has been found, only increases the hardness and toughness of the steel in its unhardened condition, while its influence on hardened steel is but small, and its presence causes uncontrollable irregularities in the hardening process. Titanium and vanadium have made their entry into steel manufacture more in name than in any other way,

* *Stahl und Eisen*, vol. xxii. pp. 579-580.

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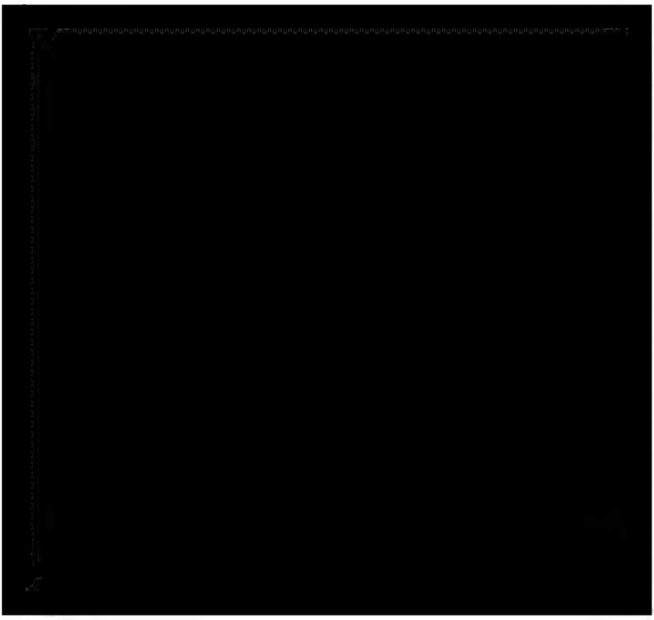


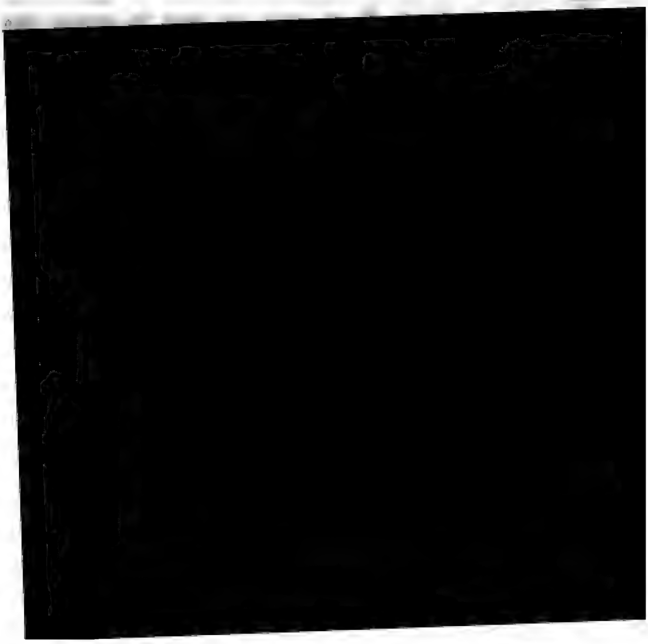
this kind, and it then possesses the best ratio of toughness and hardness. In such alloys as those above mentioned carbon forms carbides just as in ordinary steel. The author deals with the subject generally.

J. Castner * discusses Giebeler's "special steel" with reference to its value for armour-plate purposes. The inventor had this steel tested at Charlottenburg, and it was found that it attained a maximum tensile strength of as much as 103·5 tons per square inch. It then showed, however, no elongation whatever. Based on these results, Giebeler claimed that this steel was twice as hard as the best ordinary kinds of steel, and that cannon made from it would be 140 per cent. stronger, and armour plates might be 50 per cent. lighter than those now in use. It is, however, the author observes, a fundamental error to assume that hardness alone is a measure of the good quality of a steel. Least of all can this be true for guns and armour plate. In the case of steel for guns it is rather toughness that is required than actual strength, in order that the gun tube may be able to withstand properly the shock of the explosions inside it. A gun made of Giebeler steel would burst with the very first shot. Such steel would be equally bad for armour plates, and the author criticises in this respect the Harveyised steel plates. In these the face of the plate is at least glass hard, but the steel behind is wanting in toughness, with the result that the plates are apt to be broken up when fired at. It is in just this respect that the Krupp plates are better than those hardened by the Harvey method, the inner part of the metal being tougher, increasing gradually in this property and diminishing steadily in hardness, from the outer hard face of the plate inwards.

Dealing next with the maximum tensile strength shown by the Giebeler steel, the author mentions an instance in which the metal in an ordinary open-hearth railway carriage spring showed a tensile strength of 107·1 tons per square inch, with 6·2 per cent. elongation, and another in which crucible steel showed 108·5 tons tensile strength and 5·2 per cent. elongation, while in the case of another special steel a maximum tensile strength of 133·7 tons per square inch was observed, with an elongation of 2·4 per cent.

Another new tool steel has been invented by the Bismarckhütte, which is said to surpass in quality all former products of this class, not excepting the Taylor-White tool steel. No alteration is necessary in the design of existing machine tools to enable it to be used to full

* *Prometheus*, 1902, No. 647; *Stahl und Eisen*, vol. xxii. pp. 463–464.



H. Scherbak * advocates the advantages of welding high-pressure steam pipes by means of the Goldschmidt process. The jointing of long pipes up to 6½ inches diameter can be much more economically effected by welding than by the use of flanges.

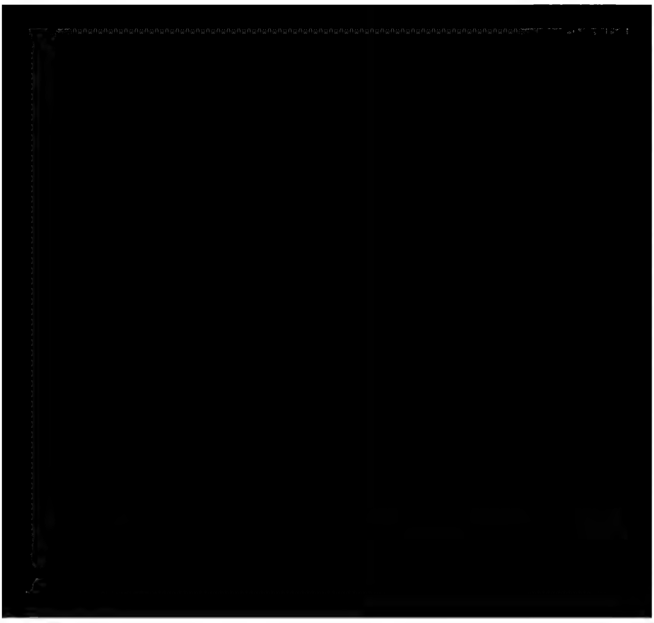
Manufacture of Wire Nails.—Of all the varied processes in the further treatment of metals, probably the manufacture of wire nails has made the least progress in the past decade.† It is true that the outputs of the machines employed have grown larger, but the character of the machines themselves has remained practically unchanged. The manufacture arose in France some eighty years ago, and down to 1854 some forty patents for nail-making machines had been taken out in France. The process was introduced into Germany about sixty years ago, and made rapid progress, Germany now being a large exporter. In 1901 these wire-nail exports from Germany amounted to 54,000 tons, valued at £550,000. In almost all other countries, too, this manufacture has made progress, and in Russia there are about twenty-five such works, with an annual production of 75,000 tons, kept active by the heavy protective duties. The common method of manufacture is described, and illustrations are given of the kinds of machines employed. A new type of machine, designed by the firm of Wikschtröm & Bayer, shown at the Düsseldorf Exhibition, is also described and illustrated. It is claimed for this machine that it entirely gets over the difficulties experienced with the machines of the type up to now in use, effecting very considerable savings in waste material, besides having about double the relative outturn.

Modern Wire-Drawing Practice.—W. Garrett ‡ discusses modern methods of wire drawing, and his account in *Stahl und Eisen* is accompanied by a series of editorial notes, which are partly intended to correct the author's statements, and partly to show in what way they agree with or differ from the methods in use at German works. The author remarks that in no branch of steel manufacture has the United Kingdom and the Continent of Europe remained so far behind the times as in the drawing of wire. The author deals in the first place with the subject from the historical point of view, attributing rolled wire to Cort. Up to that time wire

* *Zeitschrift des Oesterreichischen Ingenieur- und Architekten-Vereines*, vol. liv. pp. 698–700.

† *Stahl und Eisen*, vol. xxii. pp. 516–519, with eight illustrations.

‡ *Ibid.*, vol. xxii. pp. 545–550, with editorial comments.



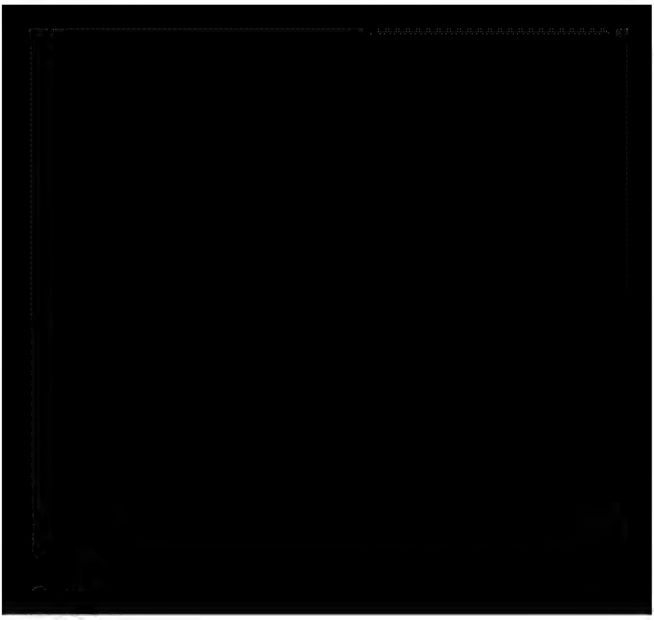
by steam to the boil; allowed to stand in this for a period not exceeding ten minutes; lifted; lowered into water; shaken for a few seconds; then transferred to another tank containing boiling milk of lime of definite strength, meal being sometimes also added; allowed to remain in this for a few minutes; then removed, and the wire subsequently charged on to a waggon, and run with this into a drying furnace, known in the United States as a "baker," and kept there for a couple of hours at a temperature of 120° to 150°, to remove the last traces of acid. It is then drawn down to a No. 18 or No. 20 size without being first annealed or subjected to any other preliminary treatment.

Armour Plates.—J. Castner * discusses the armour plates which were exhibited at the Düsseldorf Exhibition. After referring to previous papers which have related to the progress made in armour plates, and abstracts of which have appeared from time to time in the *Journal of the Iron and Steel Institute*, the author observes that it was the hardened form of armour plate, as manufactured by Krupp, accounts of which appeared in 1895 and 1896, that represented the best form of armour plate that had been manufactured up to that date. This same armour plate still holds its own, and the author gives details as to those exhibited at the Exhibition above mentioned, with the ballistic tests to which they were subjected, and the results they showed. No actual analyses are, however, given. The different kinds of armour plates described are of various kinds, rolled and cast, soft nickel steel, nickel steel hardened in oil, and nickel steel hardened on one face, and cast steel also face hardened. Armour plates for protective decks are also dealt with.

L. Baclé † describes the armour plates exhibited at Düsseldorf.

The Manufacture of Tin-Plate.—W. H. Tregoning ‡ describes the manufacture of tin-plate in South Wales, where practically all the tin-plate of the world was made until 1891. The uses of tin- and terne-plate are first referred to, and then the change from wrought iron to steel is noted. The sizes and weights of the plates are then described, and the sizes of the billets and of the economical size of the plates produced from them are discussed. The arrangement and sizes of the rolls then receive attention, and the processes of rolling,

* *Stahl und Eisen*, vol. xxii. pp. 940–953, with sixteen illustrations.
† *Génie Civil*, vol. xli. pp. 264–268.
‡ *Proceedings of the Institution of Mechanical Engineers*, 1901, pp. 1273–1282.



PHYSICAL PROPERTIES.

The Definition of Steel.—J. O. Arnold * discusses the question, "Is it possible to say what is steel, so as to obtain a sharp, legal definition which will unerringly distinguish genuine steel from its spurious imitations?" Chemical, mechanical, physical, or microscopical methods are unfortunately incapable of always distinguishing them. The chemical compositions of steel and of malleable cast iron hopelessly overlapped, and the tensile tests obtained from certain steels and from some varieties of malleable cast iron were so similar that any attempt to distinguish one from the other on mechanical data was out of the question. Physical classification was misleading, since certain varieties of malleable cast iron hardened, tempered, and let down just like steel. Certain malleable iron castings were microscopically identical with certain steels. A legal definition of steel might, however, be obtained by reference to the process of manufacture, and on this basis he had prepared a classification which sharply defined all the finished materials produced in iron and steel metallurgy. The proposed classification was as follows, and is essentially based on well-established trade terms, which imply that a specific name involves a guarantee that the material to which such name refers was substantially produced by its own specific and recognised method of manufacture :—

Malleable Wrought Iron.—The designation "malleable wrought iron" shall apply only to the products obtained by purifying pig iron in the Walloon, Franche Comté, Lancashire Hearth, or puddling furnaces, so as to produce malleable sponges or balls, from which are forged, or forged and rolled, blooms (or billets), slabs, bars, plates, sheets, or other sections suitable for the manufacture of finished articles.

Malleable wrought iron shall be distinguished from malleable cast iron by the fact that it contains unexpressed slag in the form of elongated streaks lying in the direction of the forging or forging and rolling.

* Paper read before the Sheffield Society of Engineers and Metallurgists ; *Ironmonger*, vol. ci. pp. 136-141.

Sheared Steels.—Sheared or Single Shear.—Steel faggots, bars, or finished articles shall have been manufactured from Swedish malleable wrought iron after such malleable wrought iron has been converted into blistered bar by the process of cementation. Then the blistered bar, after the operation of plating, shall have been piled and welded into a faggot, which faggot shall ultimately have been rolled or hammered into bars or shapes suitable for the production of finished articles.

Double shear steel faggots, bars, or finished articles shall have been produced by nicking into two portions a faggot of single shear steel and then welding the said portions into one faggot, which faggot shall ultimately be rolled or hammered into bars or shapes suitable for the production of finished articles.

Cast Steel.—The words "cast steel" on blooms (or billets), slabs, bars, plates, sheets, or finished articles shall be deemed a guarantee that the material from which such blooms (or billets), slabs, bars, plates, sheets, or finished articles were made was cast in a fluid condition from a crucible into an ingot, and that such ingot was afterwards forged or rolled, or forged and rolled into the said blooms (or billets), slabs, bars, plates, sheets, or into other sections suitable for the manufacture of the said finished articles.

Steel.—The word "steel" on blooms (or billets), slabs, bars, plates, sheets, or finished articles shall be deemed a guarantee that the material from which such blooms (or billets), slabs, bars, plates, sheets, or finished articles were made was cast in a fluid condition into an ingot, and that such ingot was afterwards forged or rolled, or forged and rolled into blooms (or billets), slabs, bars, plates, sheets, or into other sections suitable for the manufacture of the said finished articles.

Steel Castings.—The term "steel casting" shall imply a guarantee of (1) a casting which, after annealing, shall have undergone only a surface oxidation of its carbon, and in which casting the strength and ductility developed by the operation of annealing shall be mainly due to a recrystallisation of the metal, and not to any considerable oxidation of nor change in the condition of the carbon; or (2) a casting of such chemical composition that such casting possesses initially the amount of strength and ductility necessary for the purpose for which such casting is to be raised.

Malleable Cast Iron.—Articles moulded and cast into shape, and then annealed so as to be made more ductile (*a*) by a complete or partial oxidation of their carbon, or (*b*) by a change in the condition

of their carbon, either alone or accompanied by a partial oxidation of their carbon, shall be defined as "malleable cast iron," and never as cast steel, steel, or steel castings.

Exemptions.—The definitions of cast steel and steel shall not apply to special alloys of iron which are most suitable for use in their cast state, and which, therefore, do not require forging or rolling, or both, to produce in such alloys the requisite physical properties for the purposes for which they are employed. Such alloys, when cast from a crucible, may be legally marked either cast steel or steel, and when cast from an open-hearth or other furnace, or from a Bessemer or other converter, may be legally marked steel.

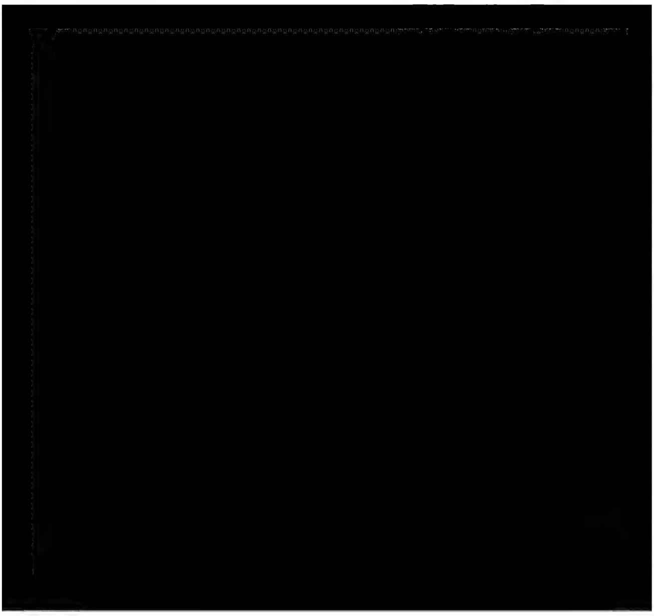
In addition to these definitions and to comments on the outcome of an action arising from the trade-marking of certain forks as steel, the author gives a very interesting historical review of this question as affecting Sheffield, and shows that it is not the first time that the case has arisen.

C. H. Ridsdale * points out the wide range of material covered by the term steel, and shows that the definitions given in the *Encyclopædia Britannica* were correct at the time. It is thought that steel might be defined or classified by a selection of at least two of the properties chosen from mechanical, physical, or chemical data. What is wanted is not a definition applicable to steel generally, but a division of the ranges of steel into several typical classes with reasonably widely-defined limits not only of composition, but also possessing certain properties and standing prescribed tests. It would not be fair to base the classification on the process of manufacture, as the vital point is that the properties be right, and, provided they are, process is immaterial.

Specific Heat.—B. V. Hill † has investigated the specific heat of alloys containing nickel, cobalt, manganese, and iron between 180° and 1000° C. It is concluded that the specific heat decreases with an increase in permeability.

Metallography.—A. Sauveur ‡ discusses the application of metallography to foundry work, and deals with the following points: The close analogy between the structure of cast iron and the structure of steel; the appearance of wrought iron under the microscope;

* *Ironmonger*, vol. ci. p. 234.
† *Electrical Review*, 1902, pp. 403–404.
‡ *Journal of the American Foundrymens' Association*, vol. xi. Part II. p. 69.



A. Sauveur * gives a review of the progress of metallography during 1901, and mentions specially the effect of that science on the rolling temperature for finishing steel rails.

Structural Changes in Overheated Steel.—K. F. Göransson † gives the results of a research carried out by him at Columbia University on the changes of structure in overheated steel. A steel, he says, which by overheating has become coarsely granular can, as is well known, be brought again to fine-grained structure by suitable heating. The author has investigated this matter, the subject forming an examination thesis in the laboratory of H. M. Howe. After referring to past investigations in this direction, the author observes that in his own experiments a hard Bessemer steel was used of the following chemical composition :—

Carbon.	Silicon.	Manganese.	Sulphur.	Phosphorus.
1·20	0·030	0·230	0·002	0·028

the temperature being determined by the aid of a Le Chatelier pyrometer. The points Ar_1 and Ac_1 were found to lie respectively between 690° and 700° C. and 740° to 750° C. The point A_3 could not be determined. The steel was heated to 1270° C., and then cooled down during a period of forty-five minutes in the same furnace. They were subsequently re-heated, and the author shows the way in which the pearlite, martensite, and other forms of iron changed into each other during this treatment.

The Electric Resistance of Steel and Iron.—C. Benedicks ‡ discusses the electric resistance of steel and of pure iron. The hardness of a metal is largely affected by those substances that are dissolved in it; it is probable, too, that equivalent quantities of, for instance, H., C., Cr., W., &c., cause similar increases in the hardness of iron or other metals if homogeneously dissolved in them. It has long been known that the degree of electric conductivity of a metal is closely connected with the relative hardness, and it is to be assumed is dependent on the same causes. To ascertain, in part, how far this might be true, the author has made a series of investigations, the results of which he now gives. The material examined was the so-called Gysinge electro-steel, made from Danne-

* *The Mineral Industry*, vol. x. pp. 699–709.
† *Jernkontorets Annaler*, vol. lvii. pp. 170–188.
‡ *Zeitschrift für physikalische Chemie*, vol. xl. No. 5.

$\sigma = 9$. Assuming the existence of several allotropic forms of iron, they must all, the author shows, possess the same electric resistance. It is not at all necessary to assume, he says, that γ-iron is harder than α-iron, the difference being solely due to the larger quantity of dissolved substances. The author considers further that the existence of the 0·27 per cent. of dissolved carbon to which he has drawn attention is identical with that of the sorbite also observed. The author has also dealt in another paper with the magnetic condition of magnetised cylinders.

Magnetic Properties of Iron.—In a report on the magnetic properties of iron and steel at liquid air temperatures, Trowbridge * discusses the magnetic permeability of liquid oxygen and of liquid atmospheric air. The behaviour of permanent magnets and the permeability and hysteresis of iron and steel at very low temperatures is considered.

R. Richter † publishes an account of an apparatus for the magnetic testing of iron sheets which enables the whole sheet to be tested, and not merely a piece cut out of it. It has been tested experimentally by Siemens and Halske, and was found to give satisfactory results. It is now being further tested by the *Verband deutscher Elektrotechniker* to ascertain whether it is worthy of recommendation for general acceptance as a standard apparatus in place of that of Epstein.

G. F. C. Searle ‡ and T. G. Bedford describe their method for measuring hysteresis and the relations between hysteresis and tension and torsion in iron and steel wires.

R. Hiecke § discusses Dina's experiments on hysteresis in a rotating field.

J. A. Ewing ‖ points out that some doubt exists as to the permanency of the standards used in his hysteresis tester, and that it would be preferable to compare them from time to time.

E. Wilson ¶ considers magnetism in a rotating iron cylinder.

E. Wilson ** deals with the dissipation of energy by electric currents

* *Electrical World*, 1902, pp. 325–328.

† *Elektrotechnische Zeitschrift*, vol. xxiii. pp. 491–492; *Stahl und Eisen*, vol. xxii. p. 796.

‡ *Philosophical Transactions of the Royal Society*, vol. cxcviii. pp. 33–104; *Proceedings*, vol. lxviii. pp. 348–352.

§ *Elektrotechnische Zeitschrift*, vol. xxiii. pp. 142–143.

‖ *Engineer*, vol. xciv. p. 194.

¶ *Proceedings of the Royal Society*, vol. lxix. pp. 435–449.

** *Ibid.*, vol. lxx. pp. 359–374.

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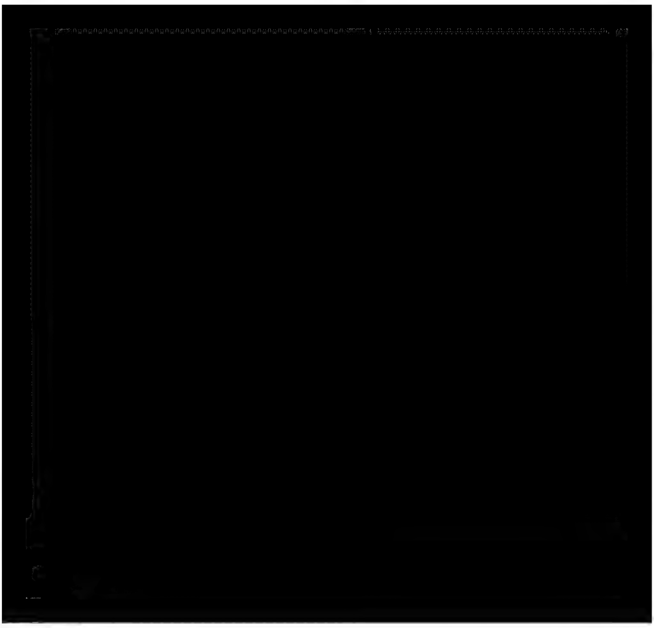


with an increase of time in cooling during annealing, and the magnetic after-effect depends on the rate and manner of cooling, and is less as the permeability is greater.

C. Barus * shows that the phenomena of magnetostriction involve viscosity and slip, and experimentally shows that in the presence of an impressed strain a longitudinal magnetic field produces increased rigidity and temporary set, and that temporary and permanent set occur in twisting, just as in magnetisation.

S. Sano † discusses and extends Kirchoff's theory of magnetostriction. H. Nayoka ‡ and K. Honda also have investigated the effect of magnetostriction or variation in length and volume of four nickel steels containing 25, 29, 36, and 46 per cent. of nickel in a magnetic field. C. E. Guillaume and F. Osmond discuss their results in view of Dumas' theory and also in other ways.

P. E. Shaw § and S. C. Laws have added further information on this subject by continuing their experiments with Shaw's electric micrometer. Rods of various diameters of Swedish iron, mild and hard steels were tested. The ultimate molecular behaviour, even of samples of similar composition and well annealed, seems to be very irregular, and the effect of varying the field is discussed.

G. Barlow ‖ gives the results of an investigation having for its object a more exact determination of the relation between the change of resistance and the magnetisation of iron and nickel. The hysteresis of resistance was found to be of such importance that this phenomenon was separately examined.

A. Gray ¶ and A. Wood describe some experiments made by them to determine the effect of a longitudinal magnetic field on the internal viscosity of wires of nickel and iron, as shown by change in the rate of subsidence of torsional oscillations.

C. Benedicks ** gives an account of his researches in the polar distance of magnetised cylinders.

A summary of the contents of William Gilbert's book on the magnet, published in Latin in 1600, has appeared. ††

* *Physical Review*, vol. xiii. pp. 283-306.

† *Ibid.*, pp. 158–170.

‡ *Comptes Rendus de l'Académie des Sciences*, vol. cxxxiv. p. 536–539, 596–598.

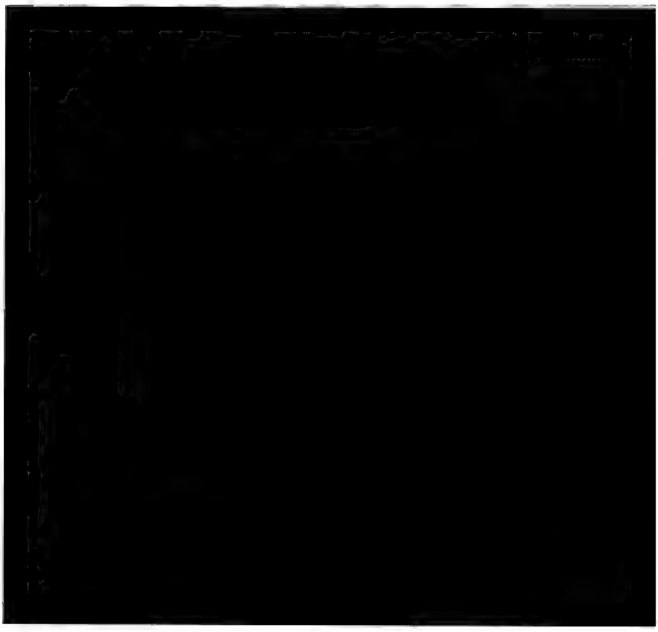
§ *Electrician*, vol. xlviii. pp. 699–702, 765-767.

‖ *Proceedings of the Royal Society*, vol. lxxi. pp. 30–42.

¶ *Ibid.*, vol. lxx. pp. 294-302.

** *Bihang till k. svenska vet. akad. handlingar*, vol. xxvii. Part I. No. 5.

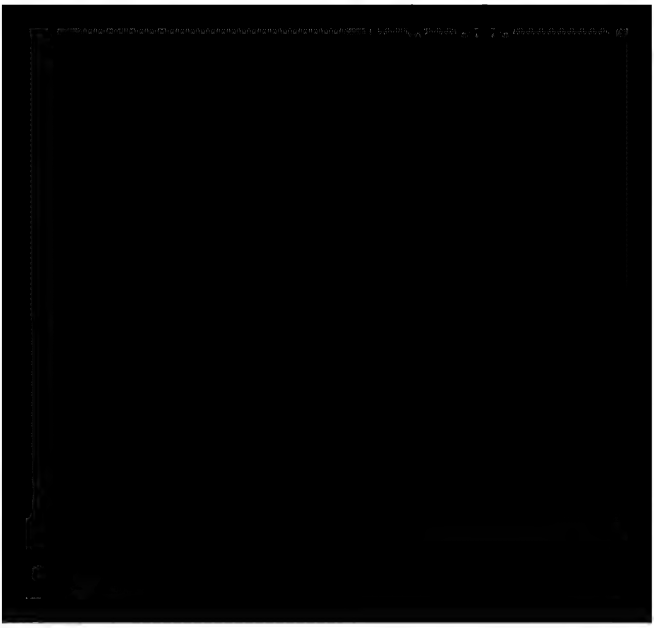
†† *Nature*, vol. lxvi. pp. 249-251.



instances such a case in which a tubular boiler was put into operation in 1897. It served to heat the working rooms, and was usually in operation from October to April, and it was cleaned about Christmas and Easter. The water used was first passed through a Reinert cleansing apparatus, and practically no deposit was found in the boiler. Cracks began to show themselves in the boiler shell in November 1899, and the rivet-holes, too, began to crack, and the riveting to become unsatisfactory. This grew worse, and in April 1901 thorough repairs were considered necessary. The author describes the nature of the injuries, and observes that their cause is to be traced to strains in the material, produced, it may be, by the treatment to which it was subjected in the shops or elsewhere, which subsequently led to the cracks when the boiler was at work, either by the general expansion of the metal or by the direct action of the flame. The metal itself was of good quality, and test pieces also showed this, but the tensile strength of the metal had increased under work and its elongation grown less, while cracks, invisible to the eye, were found in the vicinity of the larger ones. The author thinks that the fault lies in the treatment of the metal in the shops, the following being specifically referred to: (1) After the plates have been treated by the shears they are often not annealed; (2) no annealing after making the rivet-holes; (3) rolling hot instead of cold, and without subsequent annealing; (4) those portions which for one purpose or another are heated, as in punching, welding, &c., are so treated in the open smith's fire instead of in the heating furnace; (5) if, in consequence of carelessness in manipulation, the fire-plates show bulges or indentations, they are often simply worked up in the hot again. Annealing should always be performed in the heating furnace and not in the smith's fire, and bending plates hot only allowed on condition that when they leave the rolls they are still at a dark red heat, the dangerous blue heat being thus avoided. This the author thinks is difficult, and cold bending is preferable. While, too, a damaged plate should not be bettered by treatment in the hot owing to the danger from the blue heat stage, it would seem that treatment in the cold may be permissible, though this seems doubtful. Soft metal should always be used, and hard steel never.

Annealing of Steel.—W. M. Carr * points out the necessity for annealing steel castings, holding that brittleness is due to a degree of

* *The Foundry*, October 1901; *Metallographist*, vol. v. pp. 58–61.



An illustration is given * of a 300-ton chain testing machine built by the Philadelphia Machine Tool Company. The pulling and weighing mechanism are placed at the same end of the machine, which will take 90 foot-lengths of chain. The hydraulic cylinder is 16 inches in diameter, has a stroke of 7 feet, and is supplied by low and high-pressure pumps. The former is thrown out of action automatically when its pressure of 300 lbs. is exceeded, and the stroke of the high-pressure pump is adjustable. The weighing mechanism is of the compound lever type, and has two travelling weights, of which the second comes into action when the first has travelled to the limit.

Testing Cast Iron.—R. Moldenke † discusses the opinions expressed by R. Buchanan ‡ on testing cast iron, and dissents from some of them, especially from the advisability of casting the test pieces in one with the work. He prefers to cast test samples to represent material in the ladle, but agrees in the necessity for testing the work to destruction occasionally.

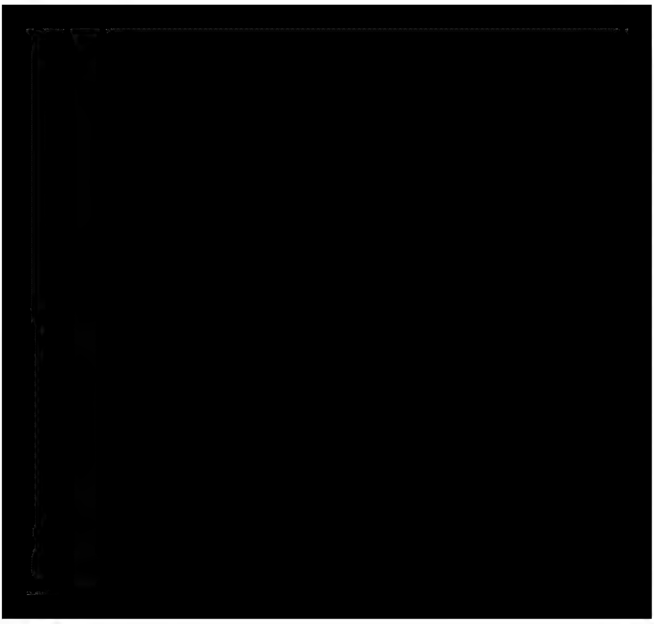
At the June meeting of the American Society for Testing Materials § much attention was given to the testing of cast iron. H. M. Howe dealt with the constitution of cast iron; R. Moldenke with the present status of testing; T. D. West with the need of foundry experience for the proper inspection and testing of cast iron; and W. Wood referred to specifications for cast-iron pipe.

The shrinkage tests used by W. J. Keep and others in the United States and other methods of testing cast iron are referred to, and the method of carrying them out is described. ||

P. Longmuir ¶ discusses the nature and properties of cast iron, and especially its strength as affected by the condition of the carbon present, and the effect of the other elements on the carbon, and on the metal directly and indirectly, including sulphur, phosphorus, silicon, and manganese.

Theory of Cast-Iron Beams.—That a cast-iron beam will bear a much greater load than that which theoretically should produce fracture is well known, and E. V. Clark ** shows that the great dis-

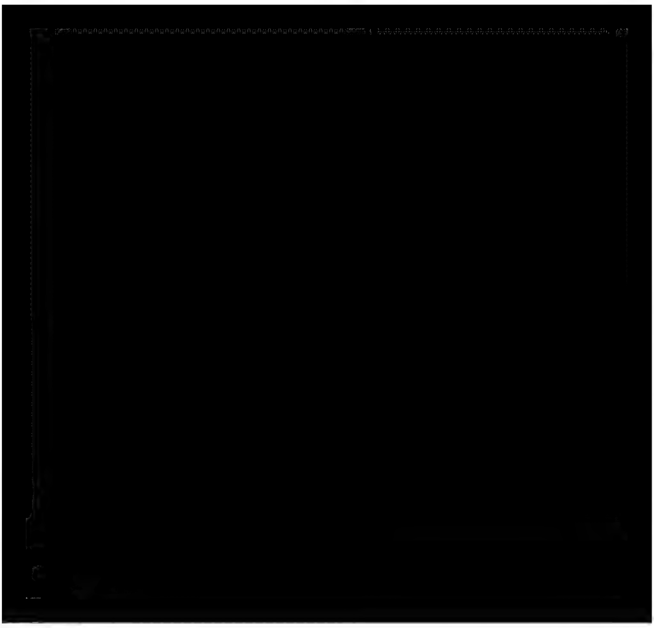
* *Iron Trade Review*, May 22, 1902, p. 43.
† *Engineering Magazine*, vol. xxiii. pp. 713-716.
‡ *Journal of the Iron and Steel Institute*, 1902, No. I. p. 624.
§ *Iron Age*, June 26, 1902, pp. 3-4.
|| *Engineer*, vol. xciii. pp. 520-521.
¶ *Journal of the American Foundrymen's Association*, vol. xi. Part I. pp. 61-68.
** *Minutes of Proceedings of the Institution of Civil Engineers*, vol. cxlix. pp. 313-341.



the size of the grain diminishing at first from that of the big-grained burnt end outwards, and then gradually again increasing. The piece which has the fracture showing the finest grain had the right temperature for hardening, and shows the greatest resistance to filing. The author next refers to v. Tetmajer's method of testing, as utilised by him in 1884–1885, and, dealing with the subject historically, mentions the various papers relating to the testing of notched test pieces since that date, a number of papers being briefly dealt with. The influence, too, of extreme cold has been experimented with in this way, and it was found that the notched samples showed the action of cold better than did those which had been left untouched. It is probable that the value of strongly notching in the case of tensile and bending tests lies in the fact that this leads to the bar fracturing between the several grains of the metal without these latter being altered in any pronounced measure either as regards their original shape or position. The experiments described by Barba at the Stockholm Congress have led to a series of further investigations, both as regards tensile and bending tests, and to these the author refers, dealing especially with those of Martens. Percussive tests made by Ast are also mentioned in some detail, as well as bending tests by the same investigator and by a number of others, their results being dealt with generally. In conclusion, the author observes that apparently, of two samples of iron of otherwise similar characteristics, that one will have the greater tendency to fracture in work which shows a granular fracture in the notched tensile test. If not one, but both, have a granular fracture, then the one with the lowest tensile strength will be the worst, and if both show the same kind of fracture and possess the same tensile strength, that one which has the higher limit of elasticity will be the least reliable. The author adds, however, that these are assumptions only, and are not yet definitely proved. There is still no method of testing with notched specimens which has been so thoroughly worked out in all its details that it could be accepted as a definite buyer's test, although as to the general value of such tests there can now be no doubt.

Armour-Plate Trials.—Illustrations are given * of the front and back of a Krupp cemented casemate plate tested at Meppen by five 6-inch projectiles weighing $112\frac{1}{2}$ lbs. each, and fired with striking velocities of 1762 to 1896 foot-seconds. The shots were broken up

* *Engineer*, vol. xciii. pp. 483–484.



S. S. Martin deals with the determination of temperature, and condemns the shrinkage test; and P. H. Dudley discusses the strength of old and recent rails, and thinks that the output need not be limited to ensure colder rolling or the manufacture of fine-grained rails.

H. Le Chatelier * comments upon the investigations carried out with the object of improving the quality of steel rails manufactured in the United States. The author summarises and discusses the results of the recent researches of S. S. Martin, R. Job, and A. Sauveur.

R. Job † discusses the relation between structure and durability of steel rails, and considers that, to ensure the most durable rail of a given composition, service tests prove that there must be absence of brittleness and freedom from foreign matter and the presence of a fine-grained structure. Absence of brittleness is shown by the ability to stand a drop test of 2000 lbs. falling 20 feet. Fine granular structure is ensured by stipulating that the temperature of the ingot or bloom shall be such that with rapid rolling, and without holding before or in the finishing passes or subsequently, and without artificial cooling after the last pass, the distance between hot saws shall not exceed 30 feet 5½ inches for 30-foot 90-lb. rails, or a proportionate distance for other lengths. Discussion on a similar paper by the same author has also ensued elsewhere.‡

* *Bulletin de la Société d'Encouragement pour l'industrie nationale*, vol. ciii. pp. 394–401.

† *Transactions of the American Institute of Mining Engineers*, Philadelphia meeting, May 1902.

‡ *Journal of the Franklin Institute*, vol. cliv. pp. 121–129.

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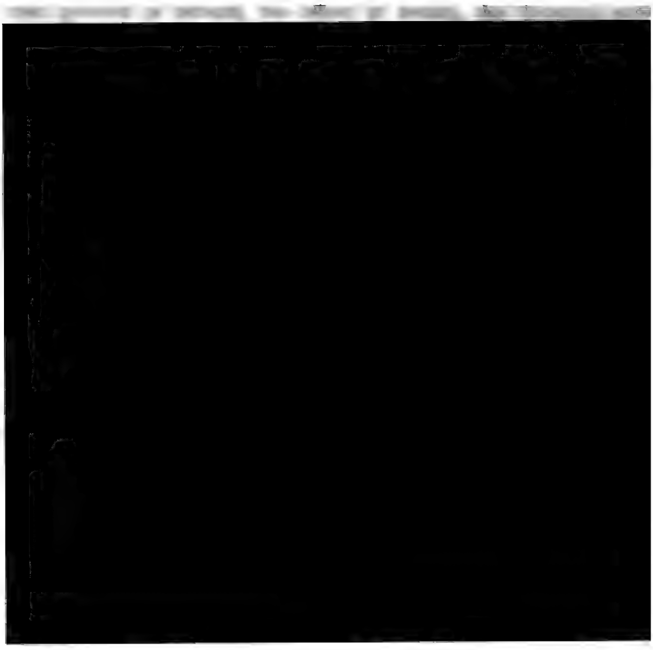

Sulphur in Pig Iron.—The properties of sulphide of iron and the state in which it occurs in cast iron are discussed by H. Le Chatelier * and M. Ziegler. As regards the chemical composition, analyses show that the proportions in which the sulphur and iron combine vary little from that of 0·8 part of sulphur to 1 of iron. A metallographical study was necessary to obtain an exact knowledge of the constitution of the substance. After polishing the surface of a fragment of sulphide of iron, without resorting to etching, three constituents may be observed. First, yellow grains, which form the principal part of the structure; these consist of the pure sulphide of iron. Secondly, shining particles with a metallic lustre more pronounced than that of the sulphide and of a white colour. Placed in a weak solution of sulphate of copper, they immediately become coated with copper, and they consist of metallic iron. Lastly, between the yellow grains and often surrounding the grains of iron a substance is visible formed of very fine lamellæ, which exhibits the usual constitution of eutectic alloys or of pearlite. One of the components of this eutectic is the yellow sulphide, the other being a greyish substance resembling in colour the slag inclusions in iron and steel. The melting-point of sulphide of iron is about 950° C. The properties of expansion at increasing temperatures are investigated, and the authors show that when heated in air sulphurous acid is set free, and oxide of iron forms. The chemical equilibrium of sulphide of iron is also considered. In conclusion, the authors discuss the state in which the substance occurs in cast iron and the influence of sulphur on nickel steels.

Influence of Silicon on the State of the Carbon Present.—A. Ledebur † observes that, while the older text-books state that in the manufacture of malleable castings the percentage of silicon present in the material must be but low, later observations showed that if good results are to be obtained at least 0·4 per cent. of silicon must necessarily be present, whilst even a higher percentage—up to, indeed, as much as 1 per cent.—could be present without bad effects, provided the carbon contents were not so high as to lead to the formation of graphite. The great advantage which crucible fusion undoubtedly possesses in this branch of the iron trade over fusion in a cupola depends partly on the fact that silicon is taken up from the material of the crucible, while in the cupola silicon is burnt out of the iron.

* *Bulletin de la Société d'Encouragement pour l'industrie nationale*, vol. ciii. pp. 368–393.

† *Stahl und Eisen*, vol. xxii. pp. 813-815.

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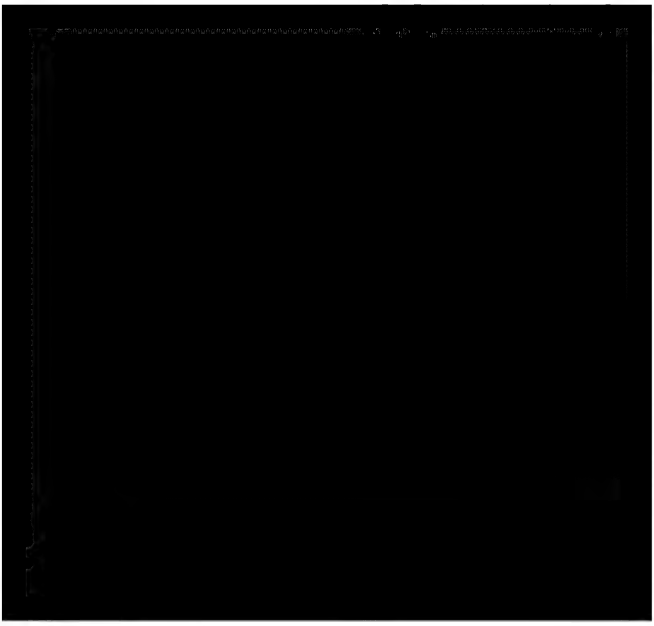
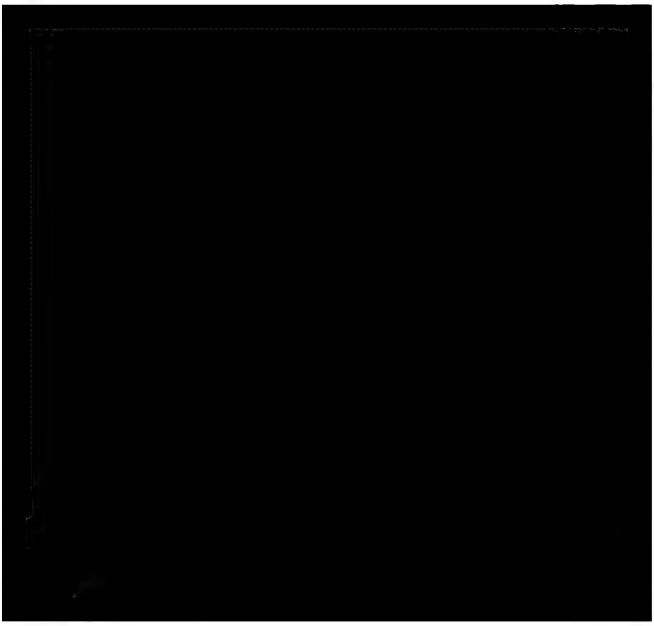


Influence of Titanium on Iron and Steel.—It is not so very long ago, observes E. Bahlsen,* that the presence of titanium in iron ores was considered a considerable disadvantage. This was largely due to experiments by Åkerman, who came to the conclusion that slags containing from 8·5 to 10 per cent. of titanic acid required more heat to melt them than did similar slags without any titanic acid. Later experiments showed, however, that this belief was inaccurate, and that, indeed, those slags which resulted from the treatment of titaniferous ores in the blast-furnace, and contained, as bases, alumina, lime, magnesia, and small quantities of ferrous oxide, were readily fusible when the oxygen in the silica and titanic acid bore to the oxygen in the above-mentioned bases approximately the ratio of 4 : 3. They become less fusible than pure silicates, however, if the base ratio becomes higher than that above-mentioned. Very small percentages of titanium, or even none at all, were found to pass into the pig iron made from titaniferous ores, and other methods than that of the blast-furnace were evidently necessary for the preparation of ferro-titanium. The Goldschmidt alumino-thermic method now admits of the manufacture of titanium alloys free from carbon, and various papers which the author mentions have of late been published on the influence of titanium on iron. Titaniferous ores are widespread in their occurrence. They contain up to some 50 per cent. of titanic acid, ilmenite having theoretically 53·25 per cent. of TiO_2. Rutile, too, which is almost pure titanic acid, is found in places in considerable quantities. Titaniferous iron ores are usually free from sulphur and phosphoric acid; but the ore from Taberg in Sweden forms an exception to this rule, containing as it does about 0·13 per cent. of phosphorus. Usually, too, they contain but little silica or other gangue, and are therefore well adapted for conversion into ferro-titanium. Some of the alloys that are made by the aid of a bath of aluminium contain from 10 per cent. to 75 per cent. of titanium, with 0·1 to 0·5 per cent. of carbon. They are of use as additions to ingot iron and steel. Other alloys, made by the reducing action of carbon, contain about 10 per cent. of titanium, together with a considerable amount of carbon. This carbon occurs as graphite, and not as combined carbon. The titanium is therefore not present in the form of a carbide. It is also found possible to produce a ferro-titanium with up to 75 per cent. of titanium, from ores which contain only 8 to 10 per cent. of titanic acid, and ores rich in titanium are not therefore

* *Stahl und Eisen*, vol. xxii. pp. 326–330.



the metal of inferior quality, being specifically lighter, flows to the top of the mould.* Instructions have been issued by boiler insurance associations to take testing strips from both ends of all long plates.

Corrosion of Steel in Sea Water.—Usener † discusses the corrosion of metals in sea water. According to him every material has a tendency to dissolve in water, the action of which depends upon the temperature. Dissolving proceeds until the osmotic pressure of the solution counterbalances the dissolving force of the material. That metals do not perceptibly dissolve, in spite of a high dissolving force, is due to the peculiarity that they only go into solution as positive ions. The metal becomes negatively, the liquid positively, charged, and the further solution is opposed by the electric forces. By placing two metals of a different dissolving force in the liquid, that with the greater dissolving force will become more strongly negative than the other, and by connecting them with a wire an electric current will flow continuously to the negative metal. The dissolving force being no longer resisted, the metal will pass into solution. The conditions are more complicated in the case of alloys, and the latter may be divided into three groups. First, mixtures such as pearlite in tempered steel; secondly, solutions like amalgams, or martensite in quenched steel; thirdly, chemical compounds, such as cementite in steel, aluminium-copper, and antimony-copper. The first group has a dissolving force equal to that of the coarsest constituent; the second has a force which lies between the dissolving forces of the constituents; and the third has a dissolving force which is independent of that of the constituents.

G. Johnstone ‡ gives some notes on the serious deterioration of steel vessels from the effects of corrosion, and states that his experience shows that steel corrodes more quickly than iron in the tropics. The points where corrosion is greatest and its causes are discussed, and it is considered that the rust should be removed periodically with wire brushes and good paint, or preservative composition applied.

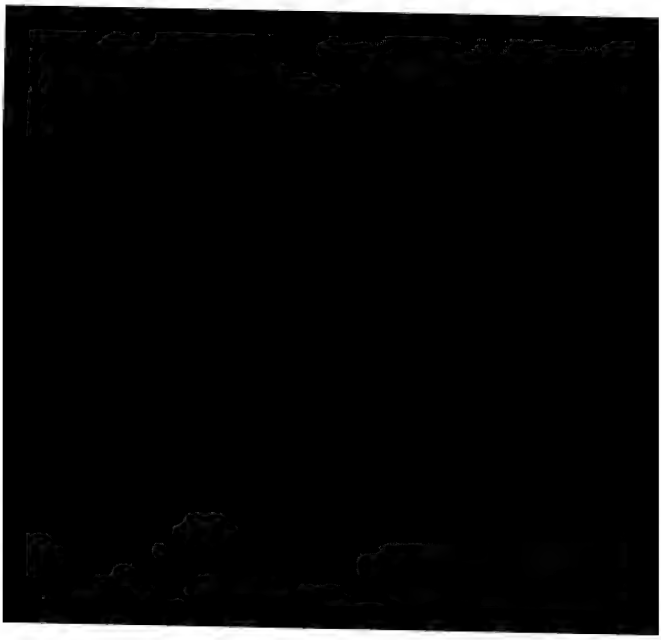
J. W. Post § concludes from observations in Sumatra that steel rails exposed to the direct action of sea water in tropical countries should be heavier than the normal sections.

* *Mittheilungen aus der Praxis des Dampfkessel-Betriebes*, 1902, pp. 632-633.

† *Zeitschrift des Vereines deutscher Ingenieure*, vol. xlvi. pp. 818–819.

‡ *Transactions of the Institution of Engineers and Shipbuilders in Scotland*, vol. xlv. pp. 71-106.

§ *Organ für die Fortschritte des Eisenbahnwesens*, 1901, p. 268.



should evidently not be allowed to be exposed to atmospheric action of this character.

Melting-Point of Manganese.—Determinations of the melting-point of manganese show it to be at about 1245° C.* The experiments were performed in a current of hydrogen, as nitrogen enters into reaction with manganese at temperatures lying between 1210° and 1220°.

* *Zeitschrift für Elektrochemie*, vol. viii. p. 185; *Stahl und Eisen*, vol. xxii. p. 1066.

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of steel were sent to different laboratories for the determination of the manganese in the metal. The following were the results returned :—

No.	Per Cent.
I.	0·49
II.	0·66
III.	0·37
IV.	0·38

No. I. was the Chemisch-technische Versuchsanstalt, Berlin ; No. II., Schmidt's laboratory, Wiesbaden ; No. III., Austrian laboratory ; No. IV., the laboratory of the Kulebaki works.

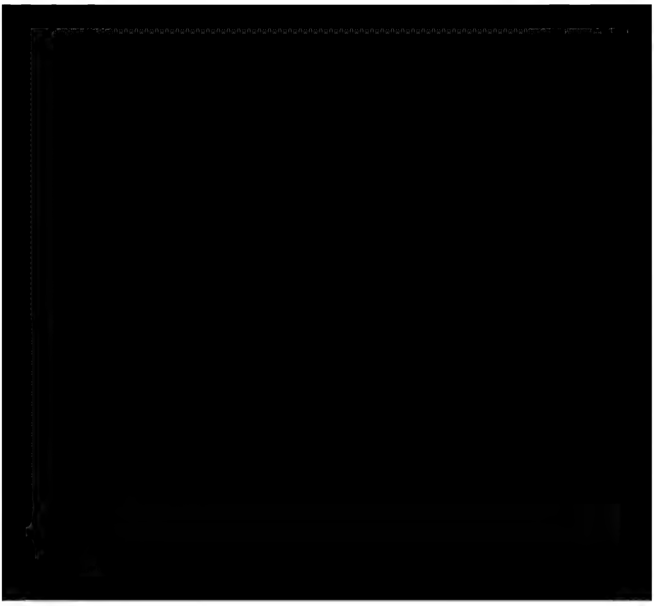
Other comparative analyses showed :—

No.	Silicon.	Carbon.	Manganese.	Sulphur.	Phosphorus.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
1	1·65	0·31	0·30	0·063	0·086
2	1·18	0·23	0·62	0·031	0·125
3	0·39	0·22	...	...	0·180

The differences were consequently very great. The author considers that the following might be considered to be permissible percentage differences : Carbon, 0·030 ; phosphorus, 0·005 ; sulphur, 0·005 ; silicon, 0·010 ; manganese, 0·030 ; and for copper, 0·005. For the determination of silicon in pig iron, he thinks the Drown method a satisfactory one, the metal being dissolved in nitric acid and then evaporated with sulphuric. For manganese in steel and pig iron, he recommends two methods—that of Deshayes for steels and pig irons with up to 1 per cent. of manganese, and the Hampe method for metals with higher manganese contents. In standardising stannous chloride and potassium permanganate solutions, the author strongly recommends the use of iron oxide. The Mohr salt gives very irregular results, and the composition of piano wire is very variable.

F. Bischoff* discusses generally the arrangements desirable in a laboratory intended for iron analysis, and the methods of analysis to be employed. The author also gives in tabular form the results of determinations by various methods of the carbon, phosphorus, sulphur, manganese, silicon, copper, and arsenic in over fifty different brands of iron. Dealing in the first place with the absence of concordance in the results of iron analyses, the author observes that these variations are usually so great as to lead to considerable difficulty in the sale and purchase of iron and steel on analysis. It is generally conceded that

* *Stahl und Eisen*, vol. xxii. pp. 719–727, 754–759, with four illustrations.



two or more from one small sample. The duration and cost of analyses are referred to, and the balances and method of weighing out are passed in review. The chief causes of inaccuracy in the analyses themselves the author considers to be the inadequate treatment of precipitates and faulty filtering generally. Then, again, alkalies are readily retained by the precipitates and filter papers; precipitates that have to be weighed are inadequately ignited or are hygroscopic; in burning the filter some of the precipitate may be lost as dust; the weighings are done at different temperatures; dust, &c., in the laboratory atmosphere; non-destruction of organic matter in certain cases; and unintentional precipitation of one substance when another is being precipitated. With regard to the permissible errors of works' determinations, the author givés in tabular form the limits which his experience has shown to be allowable in the case of iron analyses. These include:—

Maximum Permissible Variation.

Percentage Found.		Maximum Variation.		
From.	To.	C.	As, Cu, P, S, and Si.	Al, Cr, Mn, Mo, Ni, and W.
		Per Cent.	Per Cent.	Per Cent.
0·008	0·025	0·002	0·002	0·003
0·025	0·050	0·003	0·003	0·004
0·050	0·075	0·003	0·004	0·006
0·075	0·100	0·004	0·004	0·006
0·100	0·125	0·004	0·005	0·007
0·125	0·150	0·005	0·006	0·007
0·150	0·175	0·005	0·006	0·008
0·175	0·200	0·006	0·007	0·009
0·250	0·300	0·008	0·009	0·013
0·350	0·400	0·010	0·012	0·017
0·450	0·500	0·012	0·016	0·021
0·700	0·800	0·017	0·025	0·033
0·900	1·000	0·020	0·030	0·040

And for over 1 per cent., 2, 3, and 4 per cent, respectively of the observed percentage. In control analyses the check should always be done by a different method. The author next deals in detail with several methods of analysis.

Analysis of Steelworks Material.—H. Brearley * and F. Ibbotson have published a work of 501 pages on the analysis of steelworks

* "The Analysis of Steelworks Materials." London: Longmans, Green, & Co. 1902. A copy has been presented by the publishers to the Institute Library.

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proper state of admixture. A difference of some 30 per cent. was found in one sample after the bottle had been used several times and partly emptied.

To recover old copper solutions used in the determination of carbon in iron, the author boils them with potassium chlorate and hydrochloric acid.

At a conference of ironworks' chemists at Ekaterinburg, it was resolved that for the determination of carbon in pig iron the Corleis method should be accepted as a standard method. Graphite should be determined from the difference and by direct combustion.* It was further decided to determine combined carbon by the Eggertz method, using for check purposes standard solutions which were always obtainable from Stockholm. It was also decided, among other matters, to use the Dittmar mixture in the fusion of chrome ores, and to subject various methods of determining the several constituents of iron and steel to comparative tests.

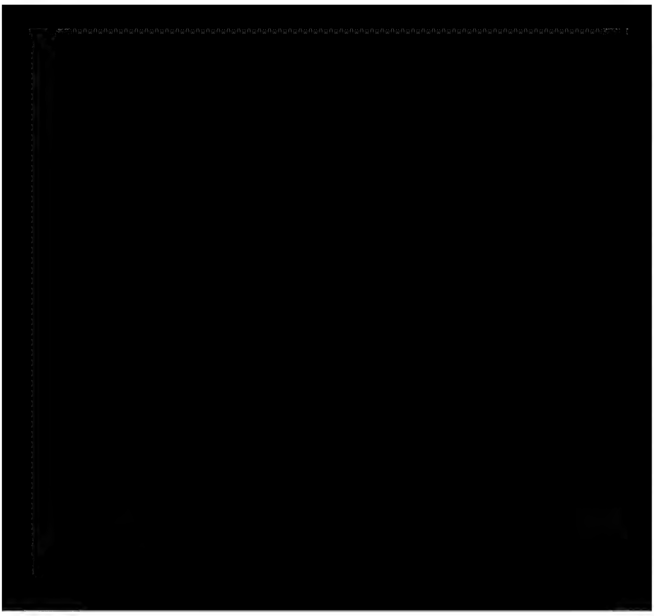
R. L. Leffler † gives a method for determining carbon in steel by direct combustion. The steel borings are sifted, and 2·5 grammes of the portion passing a 20-mesh sieve, but retained by a 40-mesh, is mixed with 6 grammes of red lead, placed in a porcelain boat, and after drying in a water-bath is burnt in a porcelain tube partially filled with copper oxide. The tube is provided with arrangements for purifying the inlet air, and with the usual calcium chloride tube and potash bulbs. A hot furnace is necessary for the combustion. Special steels, such as tungsten steel, do not require sifting.

F. Bischoff ‡ observes that the accurate determination of the total carbon is only possible by combustion in oxygen. This method can, he observes, be well effected either by the copper chloride or by the iodine method. In the former, 5·454 grammes has poured over it 220 cubic centimetres of a cupric chloride-ammonium chloride solution. This is made by dissolving 340 grammes of $CuCl_2 + H_2O$ and 214 grammes of NH_4Cl in 1850 cubic centimetres of water. At the end of twenty or twenty-two hours 6 cubic centimetres of hydrochloric acid of 1·124 specific gravity is added, and the whole heated to 40° C. to dissolve the precipitated copper, this being then completed by means of a shaking apparatus. The separated carbon is collected on an ignited asbestos filter, washed with water acidulated with hydrochloric acid, and finally

* *Stahl und Eisen*, vol. xxii. p. 443.

† *Chemical News*, vol. lxxxv. pp. 121-122.

‡ *Stahl und Eisen*, vol. xxii. pp. 754-755.



Corleis, who effects this desired result by the use of U tubes. By doing away with the combustion tube, the addition of copper sulphate, and allowing as a correction +2 per cent., the length is still further reduced. This latter method can, of course, only be employed for works' purposes. The U tubes readily choke, however, and even with their use the length of apparatus necessary forms a considerable nuisance. The author has designed an apparatus to overcome this difficulty, which he now describes and illustrates. It is of simple construction, consisting in the main of a dissolving flask, a small combustion tube and furnace, a vertical moisture-absorption vessel and a horizontal drying tube, a couple of U tubes for absorption of the carbon dioxide, and then a further horizontal drying tube, the whole being mounted on a stand and connected with an aspirator.

A. Kleine * discusses the question of the flasks used in the determination of carbon in iron and steel. The well-known Corleis flask used in the oxidation of such carbon by chromic and sulphuric acid does not, the author considers, adequately cool the gases before they leave the flask. He has, therefore, designed a modified form by which a much more effective cooling action can be obtained.

Determination of Phosphorus.—C. E. Manby † mentions the effect of annealing shot or chilled iron samples in the determination of phosphorus by the permanganate alkali method. McKenna has proved that low results are obtained with shot samples, but this defect is removed by annealing them. To effect this 2 grammes of the sample are heated to a bright red heat in a platinum crucible for two minutes. The author then gives in detail the method for determining the phosphorus in the metal.

It may be of interest to note in this connection a similar effect of annealing in the determination of sulphur.‡

F. Bischoff § observes that the method in which the phosphoric acid is first precipitated from a nitric acid solution by molybdate and then subsequently determined as magnesium pyrophosphate is an accurate one. He adds, however, that, instead of dissolving the iron in nitric acid, iodine may be used, as in the case of carbon. This shortens the time, but some phosphorus is apt to remain undissolved,

* *Chemiker Zeitung*, vol. xxvi. p. 704; *Stahl und Eisen*, vol. xxii. pp. 614–615, with one illustration.

† *Proceedings of the Engineers' Society of Western Pennsylvania*, vol. xviii. pp. 132–136.

‡ *Journal of the Iron and Steel Institute*, 1902, No. I. p. 651.

§ *Stahl und Eisen*, vol. xxii. p. 755.

doing this some manganese is also precipitated, and it is therefore usual to redissolve and reprecipitate. It is better, however, to proceed in the following manner. The solution is first exactly neutralised with ammonia and then with ammonium carbonate in the usual way, and then transferred to a strong 3-litre flask having a 2-litre mark. Instead of boiling, the flask is connected with a Körting water air-pump, but placing a similar though empty flask in between the two. The pump being put in action, the iron begins to precipitate. If, however, the exhaustion is commenced too slowly, the solution becomes cloudy, and only clears subsequently very slowly. The second and empty flask serves to collect some water which passes over. The precipitate falls rapidly to the bottom, and only when large percentages of manganese are present is there any marked trace of manganese in the iron precipitate. The author is of opinion that no manganese really passes into the precipitate, but that the precipitate is very hard to wash free from the entangled solution. The solution in the flask is diluted to the 2-litre mark, well shaken, and allowed to settle. Then from this 1 litre is transferred to a graduated flask, and from this half of the total bulk of the solution the manganese is precipitated in the usual way and weighed as Mn_3O_4. This method requires less time and is more accurate than the ordinary one.

C. Bolin* discusses the determination of manganese in iron by means of bismuth tetroxide, and describes a new method of determining manganese in ferro-manganese and spiegeleisen.

H. P. Talbot † and J. W. Brown give a bibliography of the analytical chemistry of manganese from 1785 to 1900.

Determination of Silicon.—C. Ramorino ‡ determines the silicon in ferro-silicon of high silicon contents by slowly heating together 0·5 gramme of the finely divided ferro-silicon with 10 grammes of fusion mixture and 1 gramme of sodium peroxide. The mass is fused, allowed to cool, extracted with water and dilute hydrochloric acid; 10 cubic centimetres of nitric acid and 2 grammes of potassium chlorate are then added, and the whole evaporated to dryness on the water bath. It is finally heated to 110° C., and then taken up with 200 cubic centimetres of water and 20 of hydrochloric acid, boiling, and then filtering off the silicon. After ignition this will be found perfectly white. The manganese in the filtrate could then be determined

* *Teknisk Tidskrift, Afdelningen för kemi och bergsvetenskap*, vol. xxxii. pp. 64–66.

† *Smithsonian Miscellaneous Collections*, vol. xli.

‡ *Moniteur Scientifique*, vol. xvi. p. 18; *Stahl und Eisen*, vol. xxii. p. 447.

The methods of determination which he compares in the case of sulphur include the iodine and silver methods. In the former the metal is dissolved, as in the case of carbon, by water and solid iodine, but great care has to be taken in the filtering, as small particles of sulphur iodide readily pass through into the filtrate. After washing with hot water, the filter with its contents is charged into a porcelain crucible, covered with a mixture of nitre and caustic potash, and the whole fused. The sulphur is subsequently determined by the aid of barium chloride in the ordinary way. In the silver method, as modified by the author, the gases arising from the solution of the metal in hydrochloric acid are passed through a Liebig cooler, and are then drawn by means of an aspirator through two U tubes filled with an ammoniacal solution of silver, either nitrate or chloride. The precipitate formed is filtered off, washed carefully with ammoniacal water, and dissolved in nitric acid. The silver present is then determined by titration. This gives direct the sulphur contents, as the silver is always present as silver sulphide. Even the organic sulphur produces this same compound of silver. If it is desired to determine the two gaseous forms of sulphur separately, the total sulphur can be determined as above, and the inorganic sulphur contents determined by passing the mixture through a lead solution, the organic sulphur not acting on this. A chlorine method for the determination of sulphur is also described. All three methods give concordant results.

H. Goeckel * and J. Wolfmann have devised a modified form of the Wiborgh flask for the colorimetric determination of sulphur. An illustration accompanies their description, and they claim that their modification renders the apparatus less fragile and generally easier to manipulate.

A. Grabe † gives a number of results to show the accuracy of the Wiborgh method of determining sulphur in pig iron and steel, and illustrates the form of apparatus to be adopted.

Determination of Copper.—H. Koch ‡ recommends that, when it is a question of determining the copper contents in iron, the metal should be dissolved in dilute sulphuric acid. The copper will then collect in the undissolved residue. To effect this, 100 grammes of the filings are first covered with 200 cubic centimetres of dilute sulphuric acid of the

* *Stahl und Eisen*, vol. xxii. p. 671, with one illustration.

† *Teknisk Tidskrift, Afdelningen för kemi och bergsvetenskap*, vol. xxxii. pp. 89-92.

‡ *Zeitschrift für analytische Chemie*, vol. xli. pp. 105–107; *Stahl und Eisen*, vol. xxii. p. 989.

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of the samples contained 0·010 per cent. or less of copper, twenty-three from 0·01 to 0·05, seven from 0·05 to 0·1, while four had more than 0·2 per cent.

Determination of Arsenic.—F. Bischoff * deals with the separation and determination of arsenic and copper. Incidentally, the author observes that the opinion so widely held formerly as to the very deleterious effect exerted by copper on iron is now known to be inaccurate. In addition to this, he adds, as the iron ore workings at Dannemora and elsewhere, as for instance Siegen, have gone to the deep, the percentage of copper present has diminished. In determining the copper and arsenic in the solution of the iron, made without filtration, a current of sulphuretted hydrogen is passed for half-an-hour through the solution at a temperature of about 70° C. This is then covered and allowed to stand in a warm spot for about ten hours, when it is filtered and the precipitate washed with sulphuretted hydrogen water, keeping the whole covered as much as possible. The filter and its contents are charged into a beaker, and a solution of sodium hypochlorite added of about 10 per cent. strength. A current of chlorine is then passed through, until the solution is distinctly green in colour. After standing for a few hours, it is filtered and well washed with hot water. Hydrochloric acid is added, and by long boiling the whole of the free chlorine is driven out. The solution is then placed in a platinum dish, caustic potash is added to effect precipitation, and the whole boiled. After filtering and carefully washing, the whole of the copper will be found on the filter paper as a precipitate, while all the arsenic will have passed as arseniate into the solution. This is then acidulated with hydrochloric acid. A considerable quantity of ammonium chloride is added, and the whole made ammoniacal. After thorough cooling the arsenic is precipitated in the usual way with magnesia mixture and ammonia, ignited, and weighed as $Mg_2As_2O_7$.

Determination of Calcium.—A. Ledebur † observes that the statement of G. Watson Gray ‡ to the effect that the ferro-silicon produced in the electric furnace always contains calcium and magnesium, and, indeed, considerable quantities of the former, is so contrary to all previous beliefs on this point that a new investigation of the question seemed desirable. He therefore instituted experiments, the results of

* *Stahl und Eisen*, vol. xxii. p. 756.

† *Ibid.*, pp. 710-713.

‡ *Journal of the Iron and Steel Institute*, 1901, No. II. p. 144.

which he now gives. In the first place, however, he deals with the subject historically, and refers to the belief commonly held that the small quantities of calcium and magnesium which are occasionally observed in connection with analyses of iron are due to errors of analysis. Extreme care was therefore taken in making the analyses of the samples obtained in these tests. All the so-called pure filter papers contain some of the elements in question, and not only acid solutions, but even ammoniacal ones dissolve out the alkaline earths when filtering. The filter papers used must be therefore first very carefully washed with hot dilute hydrochloric acid and distilled water. The danger accompanying the use of large filter papers can, however, be avoided if the iron and manganese are precipitated by ammonia and ammonium sulphide in a flask of 3 or 4 litres capacity, the whole diluted to the mark, well mixed, the flask corked, and allowed to settle for some days, and the clear solution then decanted. If small quantities of the precipitate also pass over, these can be subsequently filtered off on a very small filter. The decanted solution is acidulated with hydrochloric acid, evaporated, the ammonia driven off, and the residue after solution in hydrochloric acid reprecipitated as before. The fact that the bulk of the decanted solution is not quite identical with the actual solution to be dealt with does not matter, in view of the small percentages of lime and magnesia to be determined. The reagents to be used must also be carefully examined, and the author instances a case in which the presence of magnesia was constantly observed in certain nickel analyses, with the result that it was subsequently found that the ammonia in use contained magnesia. Platinum vessels should be used where possible for evaporation.

The first experiments now described were made at the Lauchhammer ironworks. In view of the cost of pure calcium, this was replaced by calcium carbide. This carbide contained 62·5 per cent. of calcium and 37·5 per cent. of carbon. Instead of magnesium, which could not for the moment be obtained in adequate quantity, the alloy of aluminium and magnesium, known as magnalium, was employed. The experiments consisted in placing 1·5 kilogrammes of calcium carbide in the bottom of a pre-heated crucible, and then pouring on this 40 kilogrammes of the metal from the ladle after tapping an open-hearth. This iron contained 0·10 per cent. of carbon and 0·46 per cent. of manganese. The molten metal in the crucible was well stirred, and the covered crucible heated for ten minutes in a coke fire before its contents were stirred and poured. No trace of calcium was subse-

quently found in the iron, which then contained 0·13 per cent. of carbon. Similarly, 60 kilogrammes of the open-hearth metal was poured on 0·5 kilogramme of magnalium, and the whole treated as before. Aluminium was found in the product, but magnesium could not be detected. In the case of these experiments there was the possibility that the oxygen contents of the iron might have caused the oxidation of the calcium and magnesium. Other experiments were therefore made with crucible steel, calcium carbide being again used instead of calcium, but metallic magnesium being now employed and not magnalium. These experiments were made at the Annen cast-steel works. The calcium carbide very considerably increased the carbon contents of the steel, but again no trace of calcium could be found in it. A similar experiment with magnesium gave a product containing 0·002 per cent. of magnesium. Both sets of experiments therefore show that molten iron or steel cannot take up at the most more than very small traces of calcium or magnesium. Similar experiments with ferro-silicon gave identical results, but, as Watson Gray's experiments were made in the electric furnace, it seemed possible that the difference in the mode of production might be the cause of the difference in the results; and this proved to be the case, for two samples of ferro-silicon made in this way were found to contain :—

	I.	II.
	Per Cent.	Per Cent.
Silicon	28·95	33·14
Carbon	n. d.	0·29
Phosphorus	n. d.	0·05
Calcium	0·16	0·59
Magnesium	0·06	0·03

Watson Gray's investigations are therefore accurate. The author thinks that possibly in the electric furnace calcium silicide is formed, and that this is soluble in iron rich in silicon. Calcium silicide, he adds, has been frequently prepared in this way.

Instead of the ordinary method in the determination of calcium of precipitating by ammonium oxalate, Pagireff * proposes to neutralise the calcium solution, to add an excess of oxalic acid, then ammonia until the solution is slightly alkaline, and finally to boil until the excess of ammonia has been got rid of. The resulting precipitate,

* *J. russ. phys. chem. Ges.*, 1902, p. 195; *Centralblatt*, 1902, p. 1307; *Stahl und Eisen*, vol. xxii. p. 989.

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evaporated until fumes of sulphuric acid appear. When cold, 400 cubic centimetres of water is added, and the liquid is heated until solution is complete. The solution is now transferred to a litre flask, 100 cubic centimetres of ammonia of specific gravity 0·90 is added, and, after standing in cold water for an hour, the contents are made up to the mark with water. Five hundred cubic centimetres of the filtrate is mixed with 40 cubic centimetres of sulphuric acid of specific gravity 1·60, passed through the reductor, and titrated with permanganate. After deducting the amount indicated by a blank experiment, the value of permanganate in iron is multiplied by 0·605. Tungsten must be removed before the evaporation with sulphuric acid; chromium exercises an influence on the titration even when as much as 8 per cent. is present.

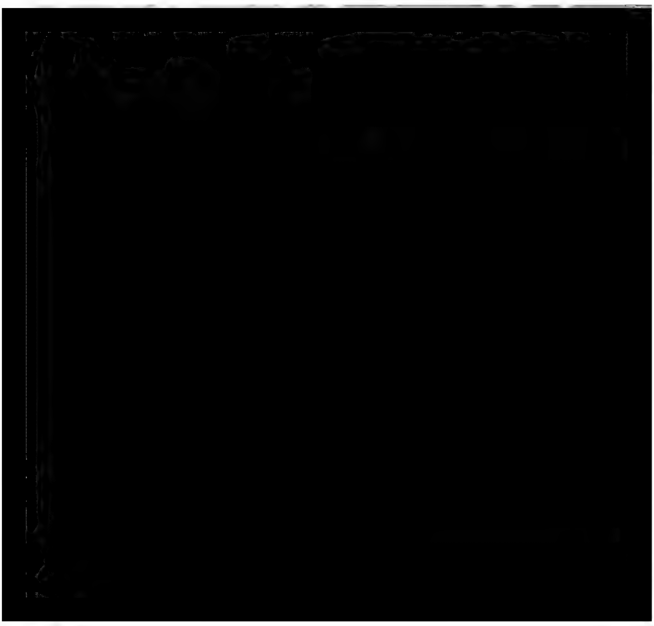
G. Auchy * dissolves 1·308 grammes of the steel in a large excess of nitric acid, with addition of a little potassium chlorate; the nitric acid is completely expelled by boiling and evaporation with hydrochloric acid, and the mass dried to render silica insoluble; a fresh quantity of hydrochloric acid is added, and the solution evaporated until a scum begins to form. Five cubic centimetres of hydrochloric acid diluted to 20 cubic centimetres with water is now added, and the mixture is heated until complete solution has taken place, when it is diluted to 50 cubic centimetres. The filtered solution is now slowly poured into a 300 cubic centimetre flask, containing 100 cubic centimetres of water and 20 grammes of sodium hydroxide, well shaken, and made up to the mark. After settling and filtering, 200 cubic centimetres of the filtrate is collected, boiled down to 100 cubic centimetres, acidified with sulphuric acid, reduced with zinc, and titrated with permanganate.

It is very important to make a blank test with steel free from molybdenum, but containing the same amount of chromium as the sample, and to be careful to use exactly the same amount of hydrochloric acid.

Laboratory Furnace.—L. Liebmann † describes a modified form of the Moissan electrical furnace. It is of simple construction, and the various details are shown by the aid of illustrations. It is claimed for it that it is always ready for use; that it is a matter of indifference whether the charge is only 20 grammes, or as much as 15 kilogrammes, or even more; that it is cheap to make and also to keep in repair; that it

* *Journal of the American Chemical Society*, vol. xxiv. pp. 273–275.

† *Zeitschrift für Elektrochemie*, vol. viii., No. 9; *Stahl und Eisen*, vol. xxii. pp. 583–584, with five illustrations.



and heating on the water bath. From this solution the iron may be precipitated by ammonia, filtered, dissolved in sulphuric acid, and reduced by zinc.

The author considers that in standardising permanganate solutions it is preferable to use an iron ore in the place of metallic iron. A very finely powdered pure iron ore is at least as equally homogeneous in composition as a wire, without being so subject to change by oxidation. The author uses, amongst others, a magnetic iron ore containing 99 per cent. of Fe_3O_4, which has the advantage that it does not take up moisture. The author first obtained in quantity enough to last him for years, and then analysed it carefully. If the Reinhardt method is employed, as it usually is, it is best to standardise with the ore in the same way as the iron is dealt with, that is to say, with a hydrochloric acid solution, as the standard so obtained differs somewhat from that resulting from the use of oxalic acid or iron in a sulphuric acid solution. Apart from the above, oxalic acid and its compounds alter somewhat with time, and can therefore only be used for standardising after careful examination.

Morgan * finds that zinc lightly coated with copper is more effective and rapid in the cold than granulated zinc or zinc dust for reducing ferric salts for titration.

Determination of Titanium.—S. Burman † describes a simple method for determining titanium in iron ores. After reduction of the finely powdered sample in a current of hydrogen and solution in dilute hydrochloric acid, the residue is fused with soda and then lixiviated with water. It is then treated with hydrochloric acid, and after addition of sodium hydrate the precipitate (titanic acid and some ferric oxide) is fused with potassium bisulphate, and the mass treated with water with the addition of alkali bisulphate. The solution is neutralised and an excess of sodium or ammonium acetate added. On boiling, the flocculent titanic orthohydrate separates out.

The Analysis of Flue Dust.—L. Schneider ‡ discusses the methods of analysis of blast-furnace dust. This, he observes, contains various poisonous cyanogen compounds. These include potassium ferrocyanide, potassium sulphocyanide, potassium cyanate, and potassium cyanide. By digestion with water a solution results which is

* *Analyst*, vol. xxvi. p. 225.

† *Teknisk Tidskrift, Afdelningen för kemi och bergsvetenskap*, vol. xxxii. pp. 76–77.

‡ *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. l. pp. 498–499.

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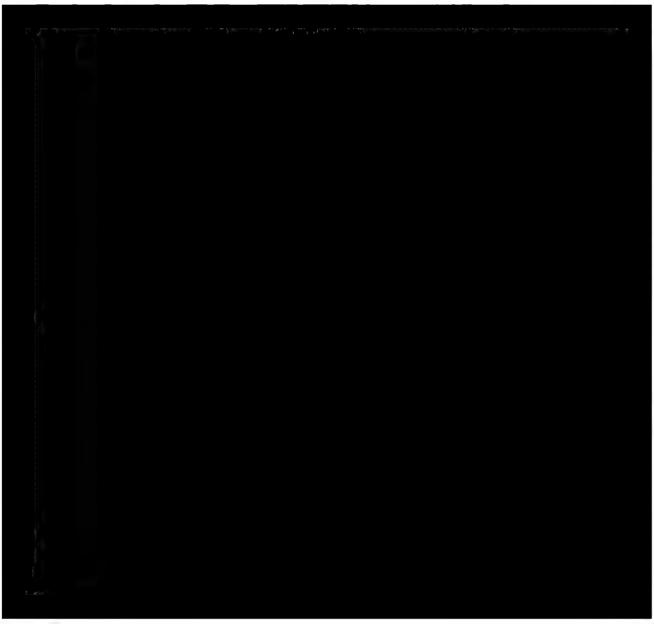
(4) The precipitate from (3) is next digested for an hour at 100° C. with a mixture of one part of water with one of strong nitric acid. This causes the whole of the cyanide compounds to pass into solution. Only silver chloride and yellow persulphocyanic acid, resulting from the decomposition of the sulphocyanide, remain undissolved. If the solution is diluted with an equal quantity of water and filtered at a boiling heat, scarcely any silver chloride worth mentioning remains in solution. The dissolved silver in the filtrate can be precipitated by hydrochloric acid, and corresponds to the three cyanide compounds—silver sulphocyanide, silver cyanate, and silver cyanide. It follows that from this—

(5) The silver cyanide can be calculated from the difference. The potassium cyanide contents of the solution may, however, also be determined direct by a very characteristic reaction. It is not precipitated in an ammoniacal solution by potassium iodide, whereas this precipitates all other silver salts from a dilute ammoniacal solution. Consequently, if the solution which is obtained by digesting the blast-furnace dust with water is treated with ammonia and ammonium carbonate, and silver nitrate is added in excess, a precipitate of ferrocyanide results, which can be filtered off. To the filtrate potassium iodide solution is added. In the presence of ammonium carbonate the precipitated silver iodide rapidly collects into lumps if shaken in the presence of an excess of potassium iodide. The silver remaining in the solution is precipitated by hydrochloric acid.

Potassium cyanide so readily undergoes decomposition by exposure to the air, with conversion into cyanate, that very little of it is to be found in blast-furnace dust.

Determination of Graphite in Ore.—A. G. Stillwell * describes a method for the determination of graphite in ore. From a quarter to 1 gramme of the sample is heated to redness in a deep platinum or porcelain crucible to drive off organic matter. It is then boiled with dilute hydrochloric acid to decompose carbonates, and filtered on to ignited asbestos. The residue is treated with chromic and sulphuric acid in an evolution apparatus, and the carbonic anhydride is collected in potash bulbs. Some results are given and also an illustration of the apparatus.

* *Journal of the Society of Chemical Industry*, vol. xxi. pp. 759-760.



is made to keep the conditions as constant as possible, and for this purpose, *inter alia*, the condensers are water-jacketed. All results are referred to those obtained from a standard coal.

Arsenic in Anthracite.—R. Job * and J. B. Young have analysed four samples of Pennsylvania anthracite for arsenic. One sample contained 0·0003 per cent. and the others none.

IV.—*GAS ANALYSIS.*

Analysis of Blast-Furnace and Producer Gases.—A. Wencelius,† discussing the methods of analysis for blast-furnace and producer gases, draws attention to the advantage of complete over other analyses. As a rule in metallurgical works, it is customary to rest satisfied with the determination of the carbon monoxide, carbon dioxide, and oxygen. Now, however, that blast-furnace gases are used direct in gas engines, more complete analyses are necessary to determine, in addition to the constituents above mentioned, the hydrogen, methane, and by difference the nitrogen. Hydrogen occurs in blast-furnace gases, and especially in producer gases, in much larger quantities than is usually assumed to be the case, and it is particularly desirable that it should be determined, especially as this can be done without difficulty. Dealing next with the methods of sampling, the author observes that the Campredon apparatus enables this to be effected with great facility, but slight modifications in the cocks used are suggested. Water saturated with common salt should be employed, as pure water dissolves a considerable quantity of gas. Two analyses of the same sample, made in the one case immediately after taking it, and in the other twenty-four hours later, gave the following results:—

No.	CO_2.	O.	CO.	H.	CH_4.	N.
I.	9·8	0·4	28·8	4·6	0·8	55·6
II.	6·8	0·8	28·5	3·7	0·7	59·5

The author therefore recommends the use of a saturated salt solution, not merely in taking the sample, but also for the graduated burette of the apparatus, if mercury is not preferred. Winkler has recommended

* *Journal of the Society of Chemical Industry*, vol. xxi. p. 693.
† *Stahl und Eisen*, vol. xxii. pp. 506–509.

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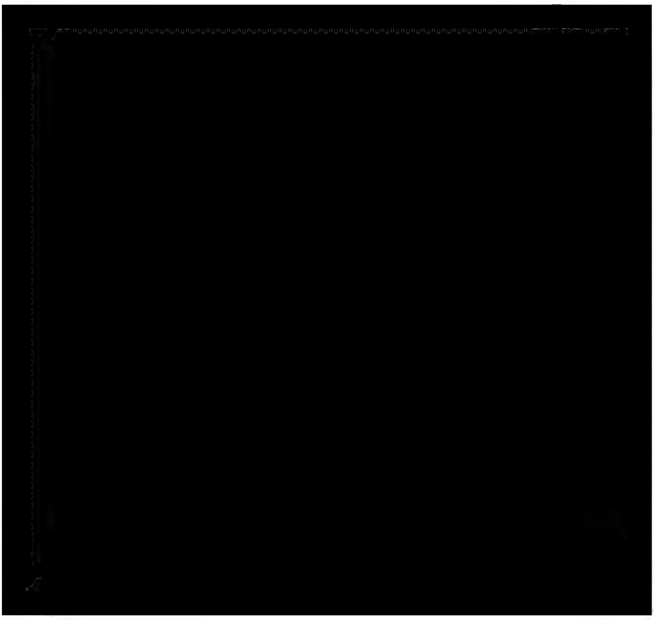

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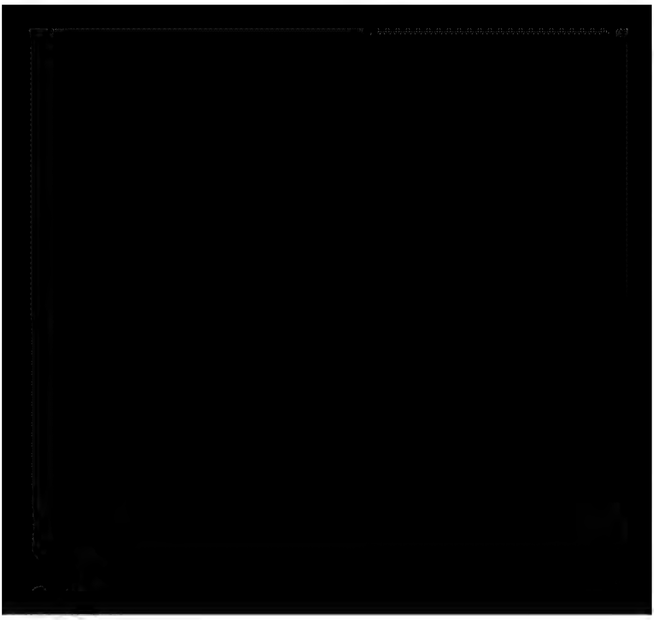
and the gas mixture passed through it. The method of calculating the analysis results is also passed in review.

A. Wencelius * also publishes a description, accompanied by illustrations, of the apparatus used by him for the analysis of blast-furnace and producer gases above referred to. The method of using the apparatus is described, and also the calculation of the results. The apparatus is stated by the author to work well, and he recommends it for use in all laboratories where many gas analyses have to be made.

Analysis of Fire-Damp.—F. Schreiber † describes the methods of analysing fire-damp.

* *Stahl und Eisen*, vol. xxii. pp. 663–667, with two illustrations.
† *Glückauf*, vol. xxxviii. pp. 863–865.



The following table gives details of the output in 1901 of the coal produced in the United Kingdom :—

	Tons.
England	153,460,284
Wales	32,686,832
Scotland	32,796,800
Ireland	103,029
Total	219,046,945

Natural inflammable gas is now being obtained in Sussex. The hope is entertained by workers in that county that the supply will be sufficient to make this mineral substance of commercial importance to the country.

Iron Trade Statistics.—The British Iron Trade Association reports * the production of iron and steel in the United Kingdom during the first half of 1902 to have included :—

	Tons.
Pig iron	4,096,478
Acid open-hearth ingots	1,529,963
Basic open-hearth ingots	241,075
Total open-hearth steel	1,771,038
Acid Bessemer steel	563,476
Basic Bessemer steel	324,902
Total Bessemer ingots	888,378

Workmen's compensation in the mining, metallurgical, and engineering industries of Great Britain is dealt with in a report recently issued by the Home Office. It presents statistics of proceedings under the Workmen's Compensation Acts of 1897 and 1900, and the Employers' Liability Act of 1880, for the year 1901.

Coke.—According to returns † issued from the Coal Trade Office at Newcastle, 4,532,645 tons of coke were made in the county of Durham last year, as compared with 5,293,015 in the year 1900; and 128,998 tons in Northumberland, as against 167,950 tons in the preceding year. In 1901, 12,573 ovens were in use in the county of Durham, and 3882 out of use, compared with 12,675 in and 3680 out of use in the previous year; in Northumberland 449 ovens were in and 214 out of use, as against 486 in and 177 out of use in the previous year.

II.—*AUSTRALASIA.*

Mineral Statistics of New South Wales.—The quantity of coal ‡ produced during 1901 was 5,968,426 tons, valued at £2,178,929,

* *Iron and Coal Trades Review*, vol. xiv. pp. 1037–1038.

† *Colliery Guardian*, vol. lxxxiv. p. 135.

‡ *Annual Report of the Department of Mines*, Sydney, 1902.

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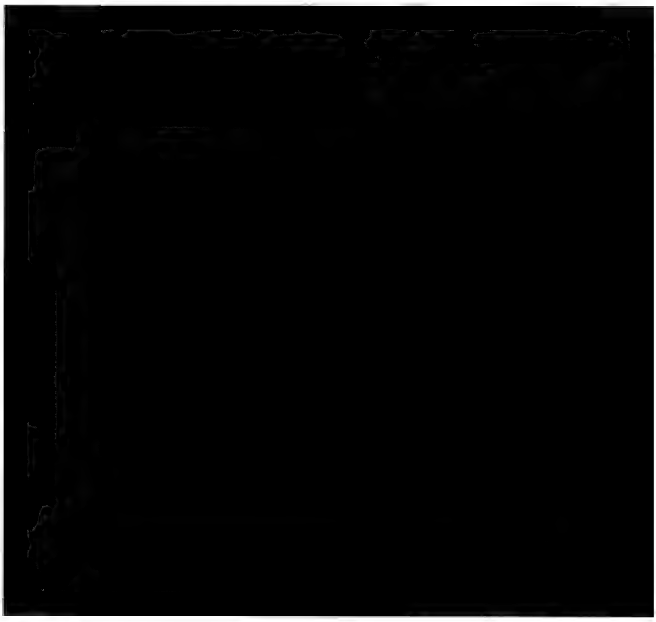


pig iron. The share taken by each branch of mineral production is best expressed in percentages, thus :—

	Of the Value of the Output.	Of the Total Number of Miners.
	Per Cent.	Per Cent.
Brown coal	48·25	40·11
Coal	42·26	47·35
Iron ore	4·45	3·95

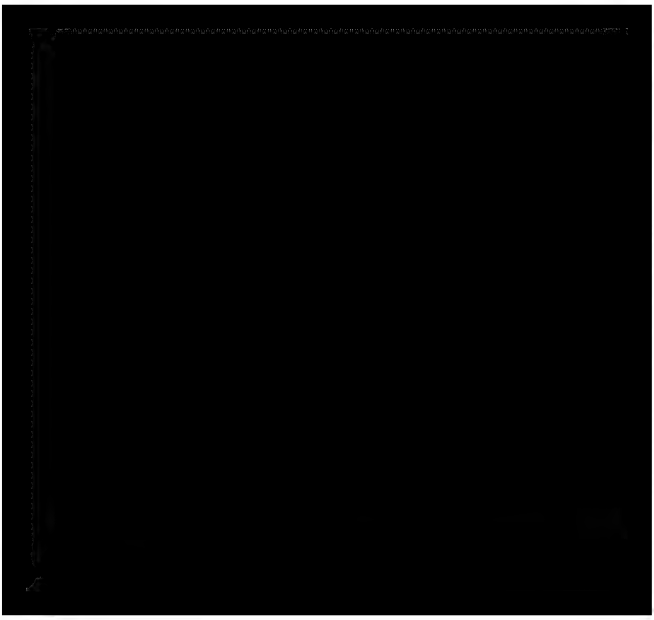
Of the total value of the metallurgical production, pig iron represented 83·08 per cent.

The Austrian Government has issued a report * on the results of the miners' sick, accident, and pension funds during the year 1899. The report contains 192 closely printed pages of tabular statistical matter, containing much information for specialists in miners' insurance.

The Foreign Trade of Austria-Hungary.—M. Caspaar † observes that there was a general depression of trade in 1901, which made itself especially felt in the iron and machinery trades of Austria-Hungary. With regard to brown coal the imports in 1901 diminished by 67 per cent. as compared with 1900, while the exports increased by 2·7 per cent. The strike in the brown coal industry in 1900 accounts for the large difference in the imports of this fuel during the two years. The imports of coal, too, for the same reason diminished by 6 per cent., and are now again normal. The exports diminished by 8 per cent. The imports of coke in 1901 show an increase of 1 per cent., and the exports an increase of 15 per cent., due to Russian demand. Almost the whole of the Austria-Hungary brown coal exports are for Germany. Most of the coal comes from the Silesian coalfields of Germany, the United Kingdom importing about one-sixth of the total coal imports. The whole of the iron ore exported goes to Germany. They showed, as will be seen from the table, a considerable reduction. The imports of iron ore from Sweden again showed an increase, whilst those from Greece had diminished in quantity. The exports of iron and iron wares diminished by as much as 36 per cent., whilst the imports only diminished by 1 per cent. Of the total quantity of these imports in 1901, 69 per cent. consisted of pig iron

* *Die Gebarung und die Ergebnisse der Krankheits-, Mortalitäts- und Invaliditätsstatistik*, Vienna, 1902.

† *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. l. pp. 259-263, 273-275.



with those for the preceding year, showing a reduction of 1711 in the number of workpeople and of as much as 65·33 per cent. in the output. There were 3 fatal and 56 severe accidents during 1900 at the petroleum plants, and 3 fatal and 15 severe ones at the ozokerite mines.

Mineral Statistics of Bosnia and Herzegovina.—Official statistics* show that in the year 1901 there were produced in Bosnia and Herzegovina :—

	Produced in 1901.	Increase or Decrease over 1900.
	Metric Tons.	Metric Tons.
Iron ore	122,569	− 10,885
Chrome ore	505	+ 405
Manganese ore . . .	6,346	− 1,592
Brown coal	445,007	+ 50,491
Pig iron	39,296	+ 335
Castings	1,445	− 176
Open-hearth ingots . .	18,120	+ 6,559
Wrought iron . . .	16,500	+ 5,922

The total quantity of charcoal made for metallurgical purposes amounted to 185,300 cubic metres. The pig iron shown in the table included 4131 tons of spiegeleisen and ferro-manganese. The workpeople employed at the collieries numbered 1478, at the iron ore mines 311, and at the ironworks 935. The total number of the workpeople employed at all mines and smelting works, including those employed in charcoal burning, amounted in 1901 to 7564, an increase of 1156, or 18 per cent., as compared with the total number so employed in 1900.

Incidentally, details are given as to the output of the mines and works belonging to the Vares Ironworks Company. The iron ore produced amounted to 121,592 tons. Of this, 70,941 tons was smelted at the company's works, and 40,914 tons exported. The miners numbered 306, the output during the year per man and per shift being 1·49 tons. The two blast-furnaces produced 26,736 tons of white pig iron, 8225 tons of grey pig iron, and 4131 tons of ferro-manganese, containing 80 per cent. of manganese. The net profit amounted to £36,000. Of this, £12,000, or one-third, went to the Government,

* *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. l. pp. 351–353 ; *Montan Zeitung*, vol. ix. p. 421.

V.—*CANADA.*

Mineral Statistics.—The mineral statistics for the Dominion of Canada for 1901 * comprise:—

	Metric Tons.
Iron ore	75,408
Chrome iron ore	1,596
Coal	5,613,689
Coke	339,043
Fireclay	1,200
Limestone for flux	153,719
Nickel ore	3,686

According to the annual report of the Minister of Mines in British Columbia, the output of coal and coke has been as follows:—

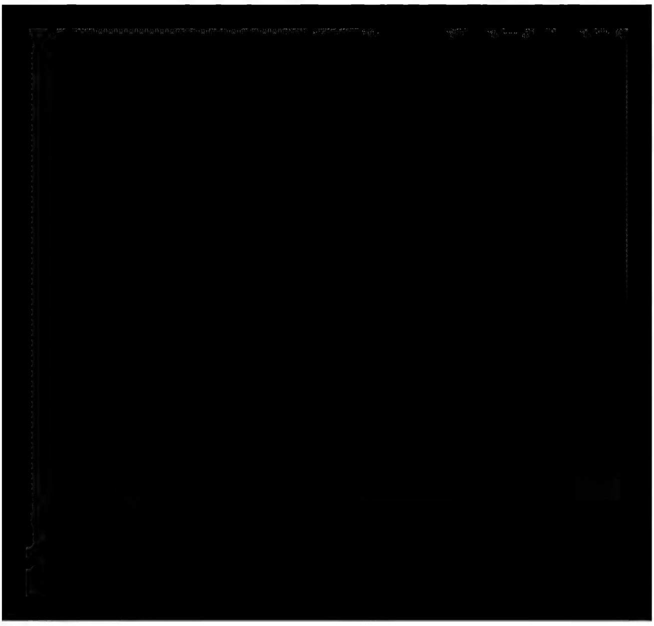
	1899.	1900.	1901.
	Tons.	Tons.	Tons.
Coal	1,306,324	1,439,595	1,460,331
Coke	34,251	85,149	127,081

The total production of coal and coke up to the end of the year 1901 has been 17,724,679 tons.

VI.—*CHILI.*

Metallurgical Resources.—In the *Boletin* of the National Mining Society of Chili, C. Vattier † gives the results of observations made by him on a journey to the iron districts of Canada and the United States, and discusses the possible application of what he saw to the ores of Chili. His memoir contains descriptions of the Radnor charcoal blast-furnaces and of the Lake Superior iron ore mines. He has prepared a special report ‡ on the application of hydraulic power in electro-metallurgy. He was instructed by the Government of Chili to investigate the new electro-metallurgical processes in Europe and America, and to ascertain their bearing on the inauguration of iron-works in Chili. He describes the recent installations in Italy, Switzerland, France, the United States, Sweden, and elsewhere. In Chili water power is abundantly available for application to metallurgical purposes.

* *The Mineral Industry*, New York, vol. x. p. 826.
† *Boletin de la Sociedad Nacional de Minera*, 1902, pp. 197–207.
‡ *Ibid.*, pp. 143–164.



District.	Metric Tons.
Rhenish Westphalia	1,542,384
Siegen, Lahn and Hesse-Nassau	278,602
Silesia	327,901
Pomerania	60,908
Saxony	—
Hanover and Brunswick	168,648
Bavaria, Würtemberg and Thuringia	62,421
Saar, Lorraine and Luxemburg	1,572,912
	4,013,776

The production during the similar period in 1901 was 3,953,779 tons. In June 1902 the works making forge pig iron and spiegeleisen numbered fifty-one, as against sixty-one in 1901; Bessemer pig iron was made by seven works in each year; basic Bessemer pig iron by thirty-one works in June 1902, and thirty-six works in June 1901; and foundry pig iron and direct castings by thirty-seven works in 1902, against thirty-eight in 1901.

Particulars of the German iron trade imports and exports for the first half of 1902 have been published.*

Imports of Iron Ore.—The imports of iron ore into Germany in the year 1901 were as follows:—

	Metric Tons.
By Rotterdam	2,957,049
By Amsterdam	268,129
Total	3,225,178

The manganese ore imported was as follows:—

	Metric Tons.
By Rotterdam	142,011
By Amsterdam	3,300
Total	145,311

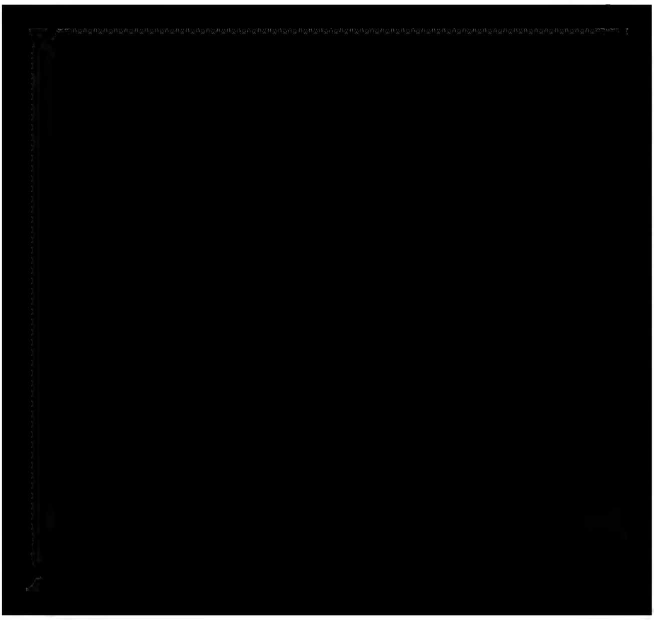
Of nickel ore, 13,213 tons were imported. Details of origin are given in connection with each of these. Of the iron ore, 1,367,016 tons were from Spain, about half of this being from Bilbao; 304,587 tons were from Algeria; 134,625 tons from Greece; and 1,041,317 tons from Sweden. Of the manganese ore, 125,467 tons were from Batoum; while, of the nickel ore, by far the larger portion was from New Caledonia.†

Mineral Statistics of Prussia.—The official statistics ‡ of the production of the Prussian mines in 1901 have just been published.

* *Stahl und Eisen*, vol. xxii. pp. 906-907.

† *Ibid.*, p. 340.

‡ *Zeitschrift für das Berg-, Hütten und Salinenwesen im preussischen Staate*, vol. l.; *Statistische Lieferung*, pp. 2-23.



Of the 40 existing coke blast-furnaces, 30 were in blast in 1901, as compared with 35 in 1900. They gave employment to 3412 male and 650 female workpeople, a total diminution of 13 per cent. The average wage of a male over 16 was £52, 15s. The furnace charges included 1,042,550 tons of ore, a diminution of 13 per cent., 38,944 tons of scrap, 333,465 tons of slag, 412,282 tons of limestone, and 830,360 tons of coal and coke. The production of pig iron amounted to 641,726 tons, a diminution of 14·1 per cent. as compared with the production in 1900. The consumption of fuel diminished by 4·5 per cent., and that of limestone by 0·6.

Only one of the two existing charcoal blast-furnaces was in operation during 1901, and that only for a period of 26·5 weeks.

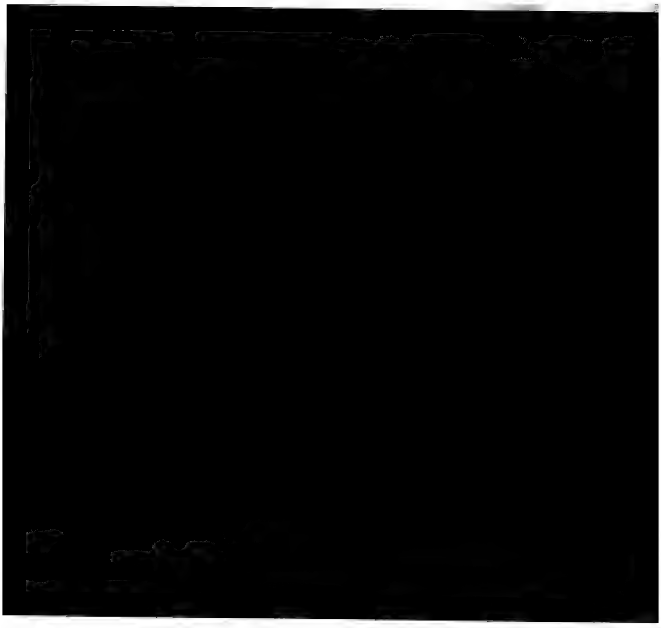
At 25 foundries, 44 cupolas, 10 reverberatory furnaces, and 9 open-hearths were in operation, and 2951 workpeople were employed. The total quantity of castings made, including 16,031 tons of pipes, was 78,375 tons, or 10·1 per cent. less than in 1900. Prices sank during the year very low, and indeed far below the actual first cost in the case of many articles.

At 22 works making weld and ingot iron, 274 puddling furnaces and a large number of others were employed, together with 66 steam hammers and 36 presses at the weld-iron works, and 10 cupolas, 2 cast-steel furnaces, 2 acid Bessemer converters and 7 basic ones, together with 26 open-hearths and numerous other furnaces, were in operation, as well as 100 rolling mills. The workpeople employed numbered 18,151, a decrease of 7·1 per cent. as compared with the number employed in 1900. The production included 188,602 tons of semi-manufactures and 501,807 tons of finished products, the total showing a decrease on the year of as much as 12·5 per cent.

The total production of iron and steel of all kinds in Upper Silesia in 1901 was 1,510,832 tons, valued at £7,395,258; 32,185 workpeople were employed, and they earned, taken together, £1,392,425.

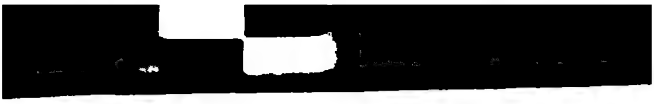
The annual report of the Mining Society of Lower Silesia * shows that, of the German production of 101,000,000 tons of coal, Lower Silesia in 1901 produced 4,709,180 tons, or 1·22 per cent. less than in 1900. There were in operation 316 coke ovens with recovery of by-products and 630 ovens without. The coke output was 513,639 tons. There were also produced 6821 tons of clay ironstone, and 85,365 tons of fireclay. The Lower Silesian collieries employed 24,107 workpeople.

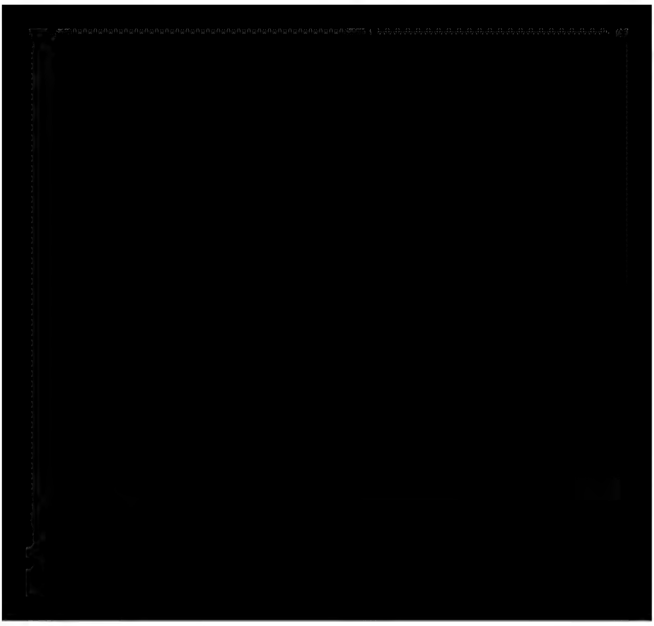
* *Glückauf*, vol. xxxviii. pp. 811–814.



workable coal that exists down to a depth of a thousand yards is placed at 30,000 million tons, while as regards iron ore the German minette district is estimated to contain 3000 millions of tons of ore, and these are not the only iron ore reserves of Germany. He next traces the rise of German ship construction, pointing out that the German Lloyd was founded only as recently as 1864. He compares ship-building in Germany with the same trade in the United Kingdom, and draws attention to the great advantage which the latter possesses in having its iron manufacturing districts close to the coast, while in Germany they are far away from the sea. When iron ship-building began, the United Kingdom with its good means of communication and its then all-powerful iron industry had a great advantage. The position is different at the present day, although Germany has not yet overcome all the difficulties that it has to contend with in this direction. By the end of the last century the production of pig iron in Germany had nearly reached that of the United Kingdom, while it actually made more steel than did this country. On the other hand, ship construction in Germany still only amounts to about one-seventh of that in the United Kingdom; and while British steelmakers look to ship construction to absorb a large portion of their output, German steelmakers are unable to find a similar market.

The author next deals with the manufacture of ship construction material in Germany. At first, owing to the requirements of Lloyd's, German ship-builders were obliged to use such materials manufactured in the United Kingdom. When iron ship-building began to give way to steel, this material used was hard, and it is to the French that the credit belongs for first making steel in quantity of a character suitable for ship construction, by the aid of the open-hearth process. In 1878 the English Lloyd's allowed ingot iron (mostly mild steel) to be used in the construction of ships and boilers with a reduction in thickness of metal, as compared with the iron previously used, of 20 per cent. for ships' hulls and 25 per cent. for their boilers. The invention of the basic process altered matters for Germany, and the rapid progress made by this process entirely changed the position. The author deals at length with the subject from a statistical point of view, showing how, with increased production and improved quality of the steel made, the dimensions of the construction materials underwent marked changes. In 1880 only about 76,000 tons of sheets and plates was made in Germany, while in 1901 the production was as much as 550,000 metric tons. The author deals with ship plates in particular,





gether unsuitable. The author therefore deals with the question of the physical properties of the different kinds of iron and steel, and in answer to the question as to what really forms the limit between soft and hard steels observes that the capacity for hardening is generally considered the criterion. There is no doubt, he adds, that a material having a tensile strength of 28·6 to 29·2 tons per square inch can be hardened, and it is as well to assume that a tensile strength of about 28 tons per square inch represents the extreme upper limit of the soft material, while if the lower limit is placed at 23·5 tons per square inch, with suitable elongation one has a mild metal which has for a long time given good results in iron-construction work and in bridges. The author deals further with the question of the relative use of hard and of soft material. An important discussion ensued on the reading of the paper.

Some time ago the German Government appointed a commission to report on the possible iron and ship-building trades of Germany in connection with their ship-building programme for the purpose of the strengthening of the German fleet. This commission * visited and inspected very thoroughly almost all the German shipyards, together with a large number of ironworks and machine shops, and then subsequently inquired into the condition of English and American shipyards and works. A report † has now been published which is based on the information thus officially collected. It is hoped that as the German iron industry now surpasses in production that of the United Kingdom, so too will ship construction in Germany make similar progress in the future.

The Teaching of Metallurgy in Prussia.—The Verein deutscher Eisenhüttenleute ‡ has addressed a memorial to the Minister for Trade and Manufactures, and also to the Minister for Education, &c., in which it is pointed out that the teaching of the metallurgy of iron, in all its varied details, has remained at a standstill of recent years at the various Prussian mining schools and technical high schools. The Government is prayed to take steps to properly endow this tuition and to bring it up to the condition of present requirements.

The memorial commences by drawing attention to the enormous

* *Stahl und Eisen*, vol. xxii. p. 798.

† Tjard Schwarz and E. von Halle, *Die Schiffbauindustrie in Deutschland und im Auslande*, Berlin.

‡ *Stahl und Eisen*, vol. xxii. pp. 589–590.

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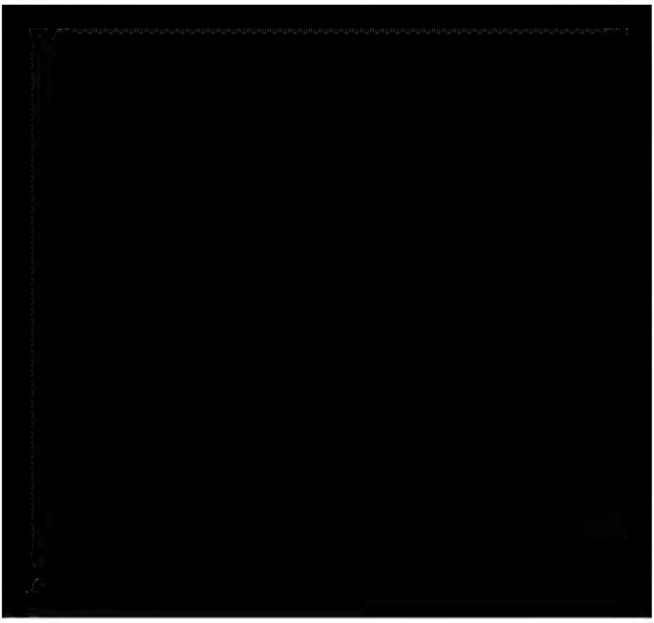


furnaces only twenty-five were in operation, the production of pig iron having been 916,404 tons.*

The Düsseldorf Exhibition.—The Düsseldorf Exhibition has led to the publication of a large amount of valuable literature. H. Wedding's paper in this volume and various memoirs already referred to deal with the mining and metallurgical exhibits. These have also been described by T. Beckert,† by E. G. Odelstjerna,‡ and by A. Gouvy.§

Descriptions have also been published by H. Dubbel,‖ by F. Kuh,¶ by F. Liebetanz,** by A. Seyfferth,†† by A. Vierow,‡‡ by C. Volk,§§ and others.‖‖

The Düsseldorf Exhibition was closed on October 20. It was visited by 4,882,459 persons, and was a great financial success. There were 2800 exhibitors, and diplomas were awarded for 216 gold medals, 447 silver medals, and 566 bronze medals. Details of the awards have been published.¶¶

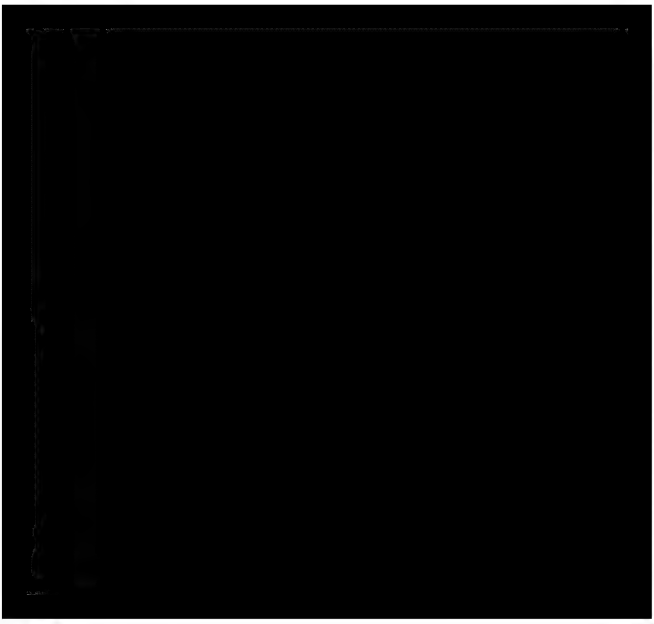
IX.—*GREECE.*

Mineral Statistics.—The mineral production of Greece in 1901 included 278,646 tons of iron ore, 196,152 tons of manganiferous iron ore, 14,166 tons of manganese ore, 4580 tons of chromium ore, 13,410 tons of crude magnesite, 2009 tons of calcined magnesite, and 9726 tons of brown coal.***

X.—*INDIA.*

Mineral Statistics.—The report of J. E. O'Conor,††† the Director-General of Statistics in India, shows that the coal industry is steadily

* *Moniteur des Intérêts Matériels*, vol. lii. pp. 2238–2239.
† *Glückauf*, vol. xxxviii. pp. 801–808.
‡ *Bihang till Jernkontorets Annaler*, 1902, pp. 241–285, 311–333, 343–362.
§ *Bulletin de la Société des Ingenieurs Civils de France*, 1902, No. II. pp. 22–134.
‖ *Zeitschrift des Vereines deutscher Ingenieure*, vol. xlvi. p. 625.
¶ *Centralblatt der Walzwerke*, vol. vi. pp. 263–265.
** *Verhandlungen des Vereins zur Beförderung des Gewerbfleisses*, 1902, p. 137.
†† *Elektrotechnische Zeitung*, 1902, pp. 399, 421.
‡‡ *Mittheilungen aus der Praxis des Dampfkessel-Betriebes*, 1902, pp. 302, 375.
§§ *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. l. p. 257.
‖‖ *Stahl und Eisen*, vol. xxii. pp. 357, 477, 541; *Eisen Zeitung*, 1902, p. 216; *Chemiker Zeitung*, vol. xxvi. pp. 577–580; *Glaser's Annalen*, vol. l. p. 179; *Dinglers Polytechnisches Journal*, vol. cccxvii. pp. 301, 309, 336, 376–386; *Bergbau*, vol. xv. Nos. 26, 34; *Engineering*, vol. lxxiii. pp. 365, 498, 605, 673.
¶¶ *Stahl und Eisen*, vol. xxii. pp. 1187–1195. *** *Montan Zeitung*, vol. ix. p. 269.
††† *Financial News*, October 25, 1902; *Colliery Guardian*, vol. lxxxiv. p. 249.



Mineral Statistics of Mysore.—The Report of the Chief Inspector of Mines * states that in 1901 there were produced 14,860 cwt. of iron ore, 2580 cwt. of iron, and 71 cwt. of steel.

Mineral Resources of the Malay States.—A report of the proceedings of the mining conference held at Ipoh, Perak, in the Federated Malay States, has been issued from the Perak Government printing office.

Mineral Statistics of the Dutch East Indies.—The Netherlands Colonial Department state that the production in the Dutch East Indies included 97,308,800 litres or 612,005 barrels of petroleum in Java; 169,842,000 litres or 1,068,189 barrels in Sumatra, together with 216,907 tons of coal from the Ombilien and Bahangan collieries; and 59,252 metric tons of petroleum and 6131 tons of coal in Borneo.†

XI.—*ITALY.*

Mineral Statistics.—The mineral and metallurgical production of Italy ‡ in 1901 comprised :—

	Metric Tons.
Pig iron	15,819
Wrought iron	180,729
Steel	123,310
Mineral fuel	425,614
Asphalt	104,874
Iron ore	232,299
Manganiferous iron ore	24,290
Manganese ore	2,181
Graphite	10,313
Coke	25,000
Coal briquettes	738,300
Charcoal briquettes	16,500

The production of petroleum amounted to 2246 tons.

XII.—*JAPAN.*

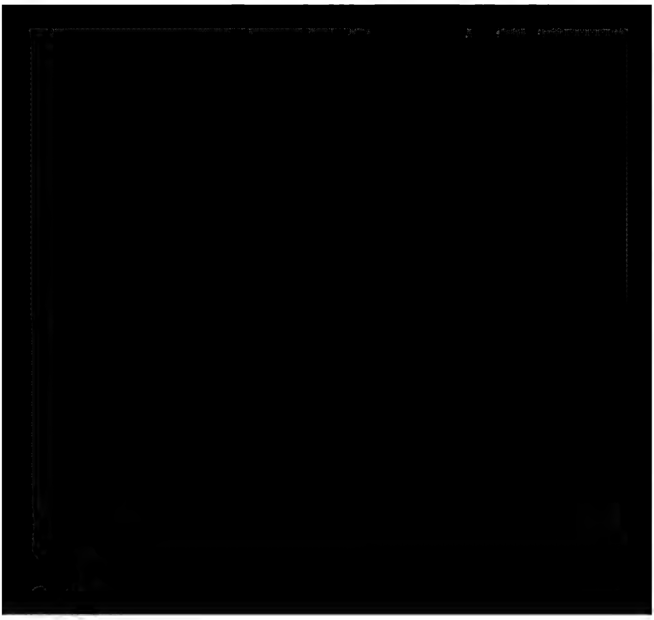
Mineral Industry.—E. Davidson § deals generally with the mineral industry of Japan, taking his details largely from an article

* *Report of the Chief Inspector of Mines, Mysore Geological Department*, Bangalore, 1902.

† *Engineering and Mining Journal*, vol. lxxiii. p. 413.

‡ *Rivista del Servizio Minerario*, Rome, 1902.

§ *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. l. pp. 249-252, 263-266, 276-278.



XIII.—*ROUMANIA.*

Petroleum.—Roumanian petroleum statistics for 1901 have been published.* The total production amounted to 270,000 tons, the share taken by the various districts being as follows: Prahova, 243,000 tons; Bacau, 14,000 tons; Dimbovita, 17,000 tons; and Buzau, 6000 tons.

Details have also been published † of the fuel consumed on the Roumanian railways, showing the rapid development in the use of liquid fuel in locomotives.

XIV.—*RUSSIA.*

Iron Trade Statistics.—In 1901 Russia produced 2,831,680 tons of pig iron, 419,786 tons of wrought iron, 1,430,562 tons of open-hearth steel ingots, 617,497 tons of Bessemer steel ingots, and 1834 tons of crucible steel. There were 183 pig iron works, 92 wrought iron works, and 67 steel works. The imports of pig iron amounted to 30,221 tons.‡

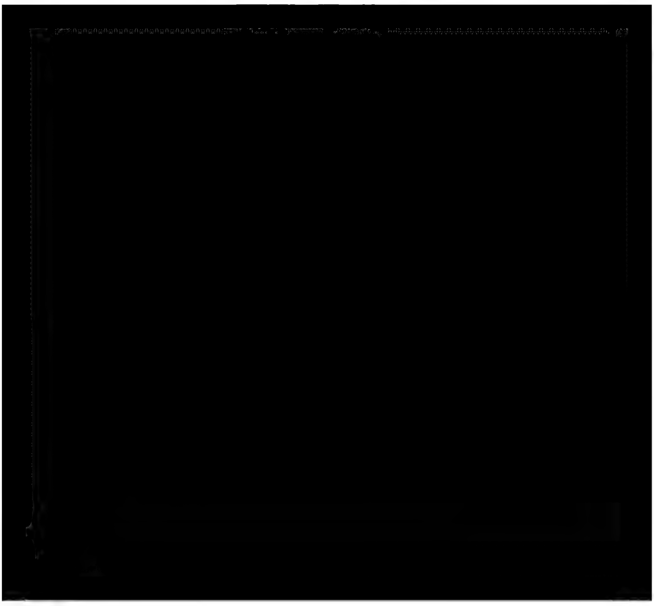
In 1901 the coal production of Russia § reached 996,078,000 poods, the highest output recorded. The production of the various districts in thousands of poods was as follows: South Russia, 694,420; Poland, 252,567; Ural, 29,742; Moscow basin, 16,007; Caucasus, 3342.

The Russian coke production ‖ in 1901 amounted to 121,648,000 poods, as compared with 137,329,000 poods in 1900. The number of coke ovens in the south of Russia was 3319.

The output of coal in Siberia is given as 275,480 tons in 1901.¶

A considerable diminution in the production of pig iron took place in Central Russia in 1901, the output amounting to only 10,580,000 poods, as compared with 14,010,000 in 1900, and 14,850,000 in 1899; while the fact that, in the first half of 1901, 6,390,000 poods was produced (62·0257 poods = 1 ton), and only 4,190,000 in the second half, points to a still further drop in the production in 1902, probably to 8,000,000

* *Moniteur des Intérêts Pétrolifères Roumains*, vol. iii. p. 709.
† *Ibid.*, p. 527.
‡ *Comité des Forges*, Bulletin No. 1980.
§ *Moniteur des Intérêts Matériels*, vol. lii. p. 1870.
‖ *Ibid.*, pp. 2978-2979.
¶ *Engineer*, vol. xciv. p. 228.



An attempt has been made * to show by elaborate calculations the feasibility of transporting electric power from the Puertollano coalfield to Madrid, a distance of 120 miles.

XVI.—*SWEDEN.*

Iron Trade Statistics.—The Swedish official mineral statistics for 1901 have been issued by R. Åkerman, the director-general of the Board of Trade.† The Swedish production comprised:—

	Metric Tons.
Iron ore	2,795,160
Manganese ore	2,271
Pig iron, all made with charcoal	528,375
Blooms produced from pig iron in charcoal hearths	164,850
Bessemer ingots and castings	77,231
Open-hearth ingots and castings	190,877
Crucible ingots and castings	1,088
Bar iron and steel	152,183
Rods, hoop iron, and steel	67,203
Wire rods	21,932
Plates (not including sheets)	13,856
Tube blanks, hollow blooms, and billets	14,333
Number of blast-furnaces in blast	139
Average daily product per furnace, tons	13·96
Average time per furnace in blast, days	272

Production of Coal.—The output of coal in Sweden ‡ in 1901 was 271,509 tons, and that of fireclay 175,876 tons. The number of miners employed was 1582. The output of the various collieries was as follows:—

Colliery.	Shafts.	Coal.	Fireclay.
		Metric Tons.	Metric Tons.
Hyllinge	1	705	1,245
Skromberga	2	49,805	13,504
Boserup	1	4,700	4,000
Höganäs	3	79,953	47,807
Billesholm	5	85,042	22,986
Ljungsgarda	1	14,799	22,410
Bjuf	2	36,471	61,376
Stabbarp	1	34	2,548

* *Revista Minera*, vol. liii. pp. 323-325.
† *Kommerskollegii Underdaniga Berättelse*, Stockholm, 1902.
‡ *Ibid.*, 1902, p. 13.

XVIII.—*UNITED STATES.*

Iron Trade Statistics.—According to the returns of the American Iron Trade Association,* the production of pig iron in the United States during the first half of 1902 was 8,808,574 tons.

The number of furnaces in blast in the United States on July 1, 1902, was 292, of a total capacity per week of 352,590 tons, this comparing with 296 furnaces, capable of producing 344,748 tons per week, on June 1. The capacity of furnaces in blast on July 1, 1901, was 310,950 tons.

Mineral Statistics.—The mineral production of the United States in 1901 is stated † to have included :—

	Tons.
Iron ore	28,887,479
Manganese ore	638,795
Bauxite	18,905
Chrome ore	368
Limestone flux	8,540,168

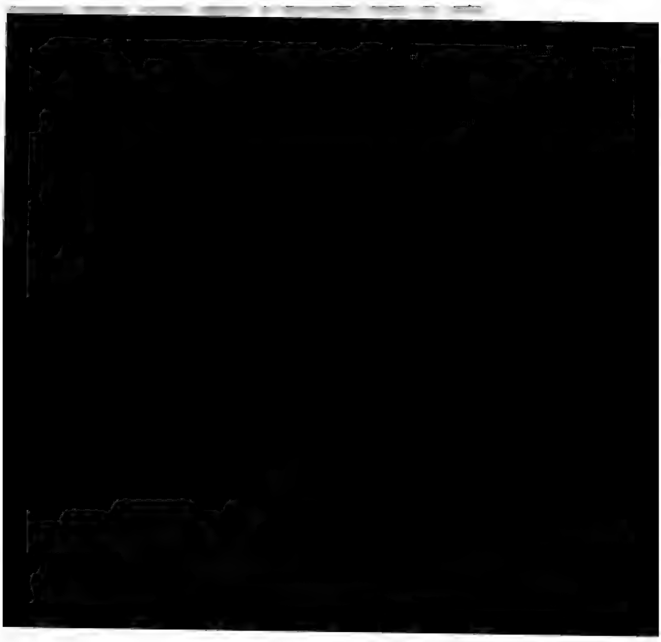
The production of petroleum was 69,389,194 barrels.

The report on the mineral resources of the United States for 1900 has just been issued by the United States Government.‡ In addition to the statistics for the year, the volume, which covers 927 pages, contains much descriptive matter. The sections on coal and coke are written by E. W. Parker. Natural gas and petroleum are dealt with by F. H. Oliphant, iron ore by John Birkinbine, and iron and steel by J. M. Swank. The volume is edited by D. T. Day.

Iron Ore.—J. Birkinbine § gives details of the production of iron ores in the United States in 1901. Twenty-five States and one territory produced ore, and, of the full details given, the following may be of interest :—

	Tons.
Minnesota	11,109,537
Michigan	9,654,067
Alabama	2,801,732
Pennsylvania	1,040,684
All other States	4,281,459
Total	28,887,479

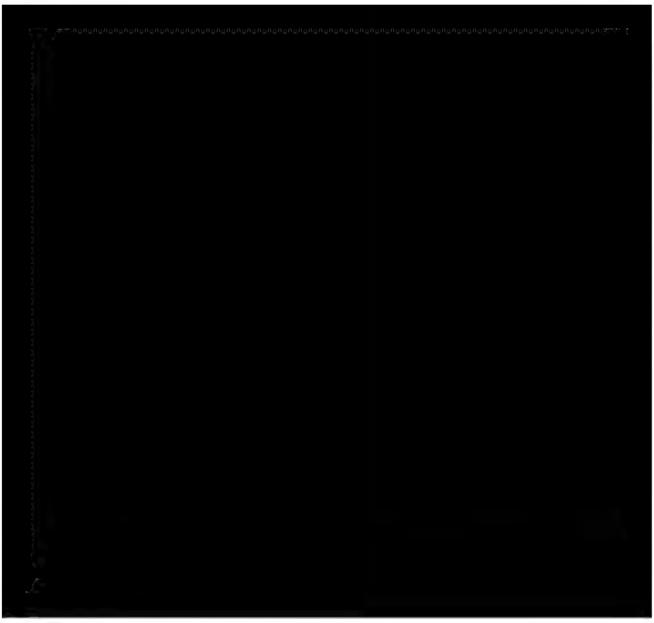
* *The Bulletin of the American Iron and Steel Association*, vol. xxxvi. p. 109.
† *The Mineral Industry*, New York, vol. x. p. 2.
‡ *Mineral Resources of the United States*, Washington, 1901.
§ *The Production of Iron Ores in 1901*; *Geological Survey*, Washington, 1902.



it must be remembered that the Pennsylvania anthracite fields are comparatively small, and are being rapidly exhausted. A notable feature in the bituminous coal industry is the disposition to consolidate the interests involved in its production. While the Connellsville deposits are not yet exhausted, it appears from the best available information that they cannot last much longer.

The American Iron Industry.—The report* of the four Commissioners appointed by the British Iron Trade Association to investigate the conditions of the American iron industry is in four main divisions, contributed by E. Parkes, A. Sahlin, E. James, and J. S. Jeans respectively. The first division, comprising a General Report on the American Industrial Conditions in relation to Iron and Steel Manufacture, has been written by J. S. Jeans, and it extends, with its twenty-two Appendices, to 486 pages of the work. It is subdivided into twelve Sections dealing successively with: I. A General Introduction and Outline; II. Raw Materials; III. Labour Conditions; IV. Organisation and Administration; V. Transportation; VI. Cost of Production; VII. Manufacture and Treatment of Finished Steel Products; VIII. Trusts and Consolidations; IX. Basic Steel; X. Collateral Industries; XI. Economic Problems; XII. Canadian Iron and Steel Industries and Canadian Competition. Section VII., on the Manufacture and Treatment of Finished Steel, is subdivided under: A. Steel Rails; B. Plates; C. Structural Steel and Bridge Work; D. Tubes; E. Tinplate; F. Wire Rods, Wire, and Wire Nails; G. Crucible Steel; H. Forgings and War Material. Each division contains accounts of the methods, output, and costs prevailing at many of the leading rolling mills of the country, and a large number of illustrations show the working details of leading types of plant and machinery. The basic steel branch is dealt with in Section IX., and the methods and conditions of its manufacture described as they prevail at such leading concerns as the Homestead, Duquesne, and Ensley works. In Section X., on American Engineering, Chapter 14 deals with iron and steel foundries and foundry operations, describing some of the later appliances and giving accounts of the foundry practice of prominent concerns. Chapter 15 treats upon the recent progress of electrical developments in the United States and the rapid growth of electric power in the driving of machinery. A typical illustration is afforded in the extensive plant of the Westinghouse Company. Chapter 17 is

* "American Industrial Conditions and Competition," London, 1902.



XIX.—*COMPARATIVE TABLES.*

The World's Production of Coal and Iron.—For purposes of comparison the following summary of the production of coal in the principal countries of the world is appended :—

Country.	Year.	Production in Tons.
United Kingdom	1901	219,046,945
Australasia—		
New South Wales	1901	5,968,426
New Zealand	1901	1,239,686
Queensland	1900	497,132
Tasmania	1901	43,000
Victoria	1901	209,329
Western Australia	1901	117,836
Austria, coal	1901	11,738,839
" lignite	1901	22,473,509
Hungary, coal	1900	1,367,189
" lignite	1900	5,130,077
Belgium	1901	22,074,000
Borneo	1900	35,368
Bosnia	1901	445,007
Canada	1901	5,613,689
Cape Colony	1900	198,451
Chili	1900	325,042
China	1900	500,000
France	1901	31,613,036
Germany, coal	1901	108,417,029
" lignite	1901	44,211,902
Greece	1901	9,726
Holland	1901	320,224
India	1901	6,635,727
Italy, lignite	1901	425,614
Japan	1900	7,429,457
Mexico	1900	38,676
Natal	1901	569,200
Peru	1900	47,500
Portugal, anthracite	1899	11,930
" lignite	1899	10,269
Roumania, lignite	1900	86,000
Russia	1900	15,652,482
Servia	1900	192,850
Spain	1901	2,567,000
Sumatra	1901	196,207
Sweden	1901	271,509
Transvaal	1898	1,938,424
Turkey	1900	270,000
United States	1901	260,929,248

A similar summary showing the production of pig iron is as follows :—

[redacted]

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The World's Production of Steel.—It is estimated * that the world's production of steel in 1901 amounted to 30,655,528 tons. In 1880 the production was 4,233,420 tons, and in 1895 it was 14,898,082 tons.

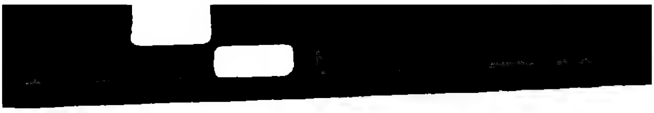
The World's Production of Aluminium.—It is stated † that the world's production of aluminium in 1901 was as follows: United States, 3244 tons; France, 1111 tons; Great Britain, 600 tons; and Switzerland, 1300 tons—total, 6255 tons. The production of bauxite in the same year was as follows: United States, 19,000 tons; France, 59,000 tons; United Kingdom, 5000 tons—total, 83,000 tons.

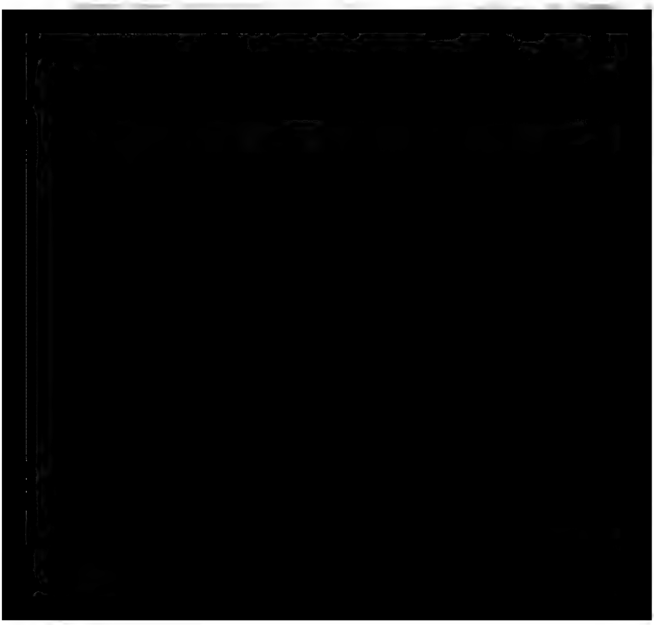
The World's Railways.—The rise and progress of the world's railways in and during the nineteenth century is dealt with in much detail,‡ each country being treated separately, and the whole shown in tabular form. The first railway in Europe was constructed in the United Kingdom in 1825, France following in 1832 and Germany in 1835. Roumania had no railway until 1870. In 1840 the total length of European railways was only 2925 kilometres (1 kilometre = 0·621 mile); in 1850 it amounted to 23,504 kilometres; in 1860 to 51,862; in 1870 to 104,914; in 1880 to 168,983; in 1890 to 223,869; and in 1900 to 283,525 kilometres of lines in operation. Of this latter length 51,391 kilometres was in Germany, the length of lines in the United Kingdom being 35,186 kilometres, France, Russia, and Austria-Hungary exceeding this, but having less than Germany. The total length of railways in the world in 1900 is estimated at:—

	Kilometres.
Europe	283,525
America	402,171
Asia	60,301
Africa	20,114
Australia	24,014
Total	790,125

Or 491,657 miles.

* *Iron and Coal Trades Review*, vol. lxv. p. 1113.
† *Echo des Mines*, vol. xxix. pp. 820-821.
‡ *Archiv für Eisenbahnwesen; Stahl und Eisen*, vol. xxii. pp. 778-783.





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[Iron slags, tinplate waste, and petroleum residues are among the subjects dealt with.]

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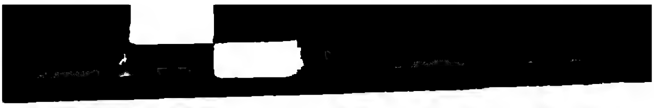

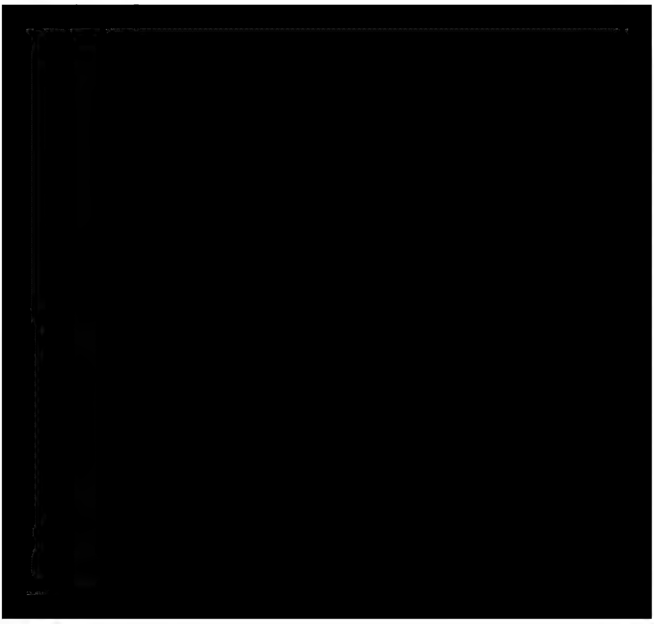

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[This volume contains the mineral statistics of the United States and other countries for 1901, together with memoirs on modern improvements in the manufacture of pig iron by John Birkinbine, on metallography by A. Sauveur, on alloys as solutions by J. A. Mathews, on magnetic concentration by H. A. J. Wilkens, on chrome iron ore in New Caledonia by F. Danvers Power, and other papers of metallurgical interest.]

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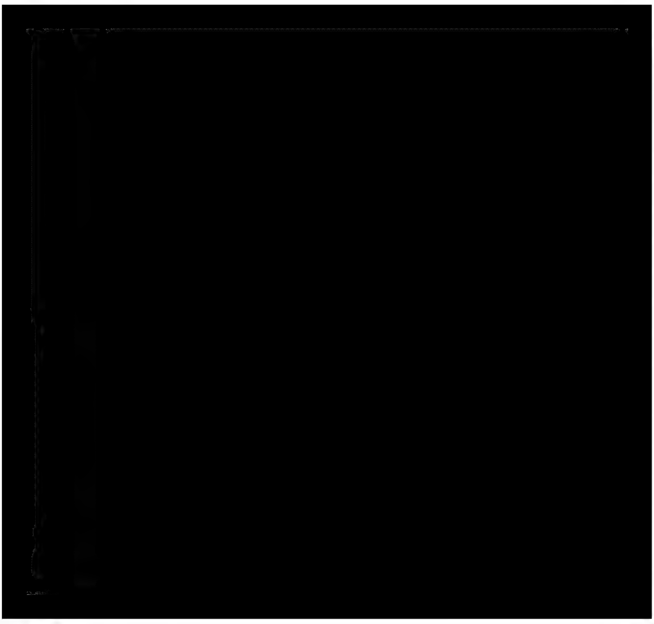

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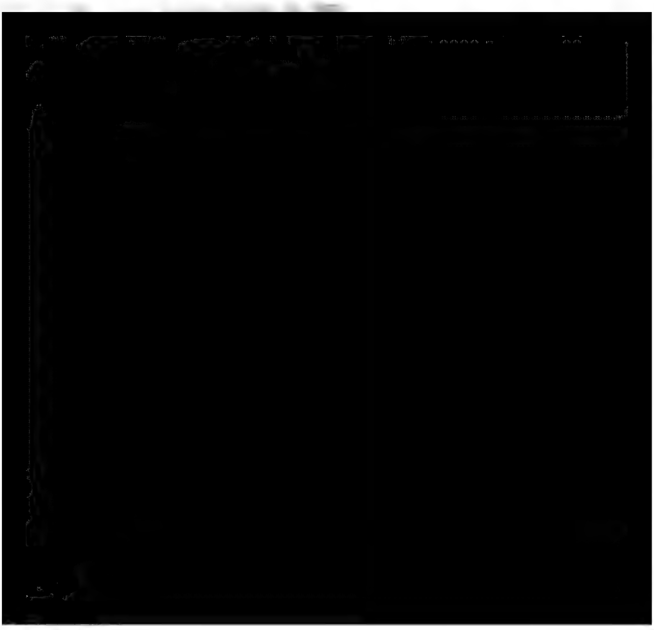

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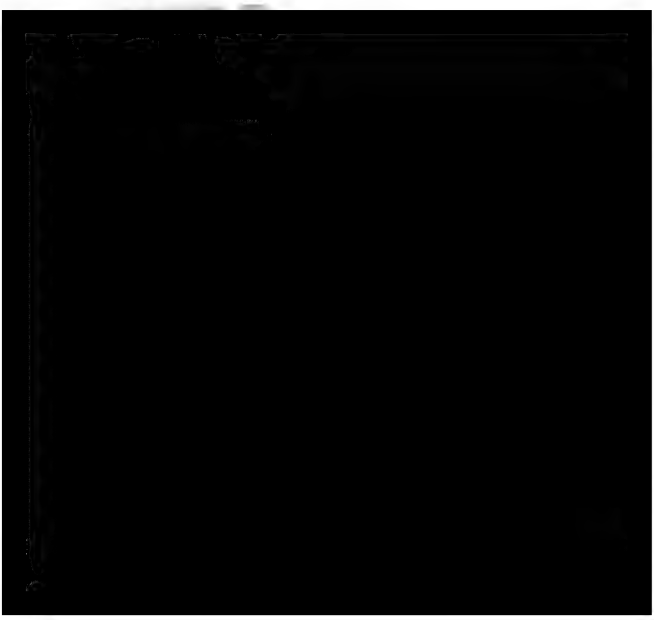

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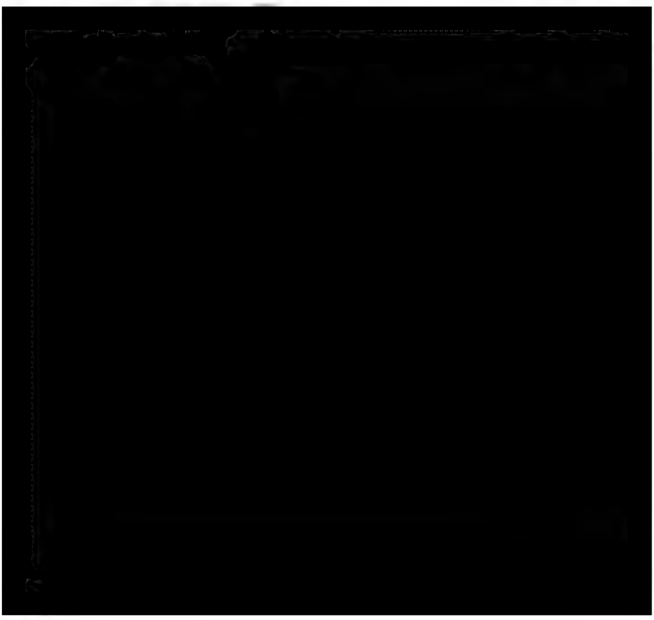

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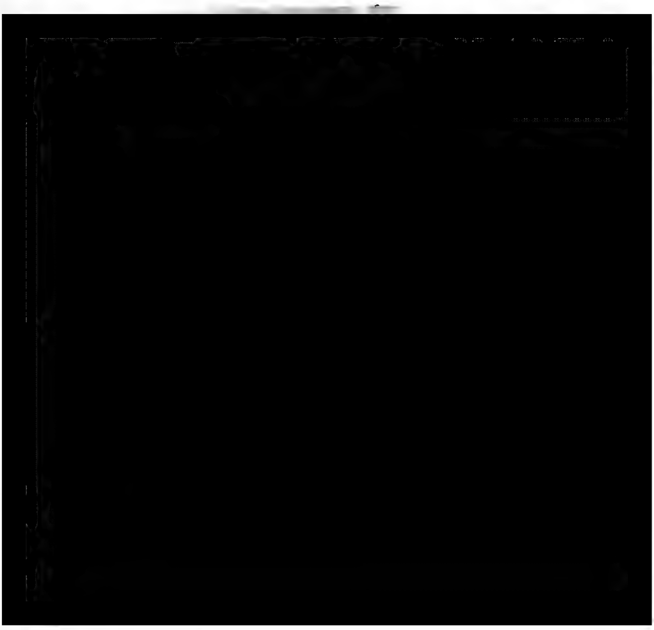

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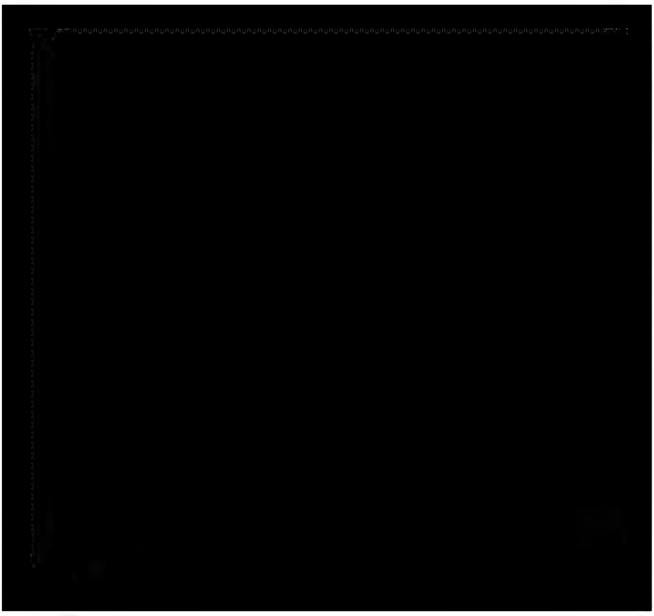

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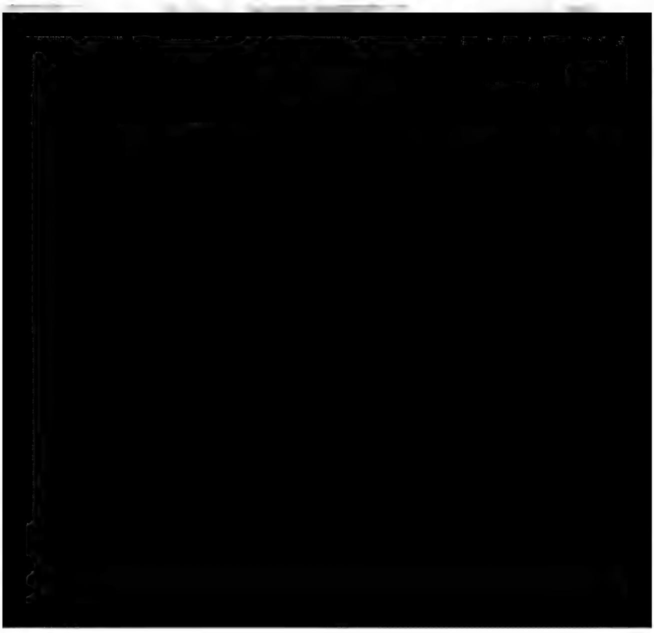

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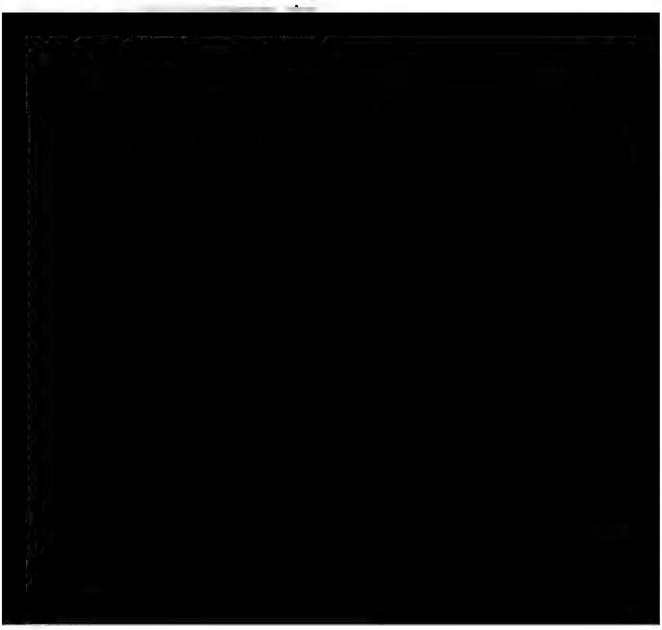

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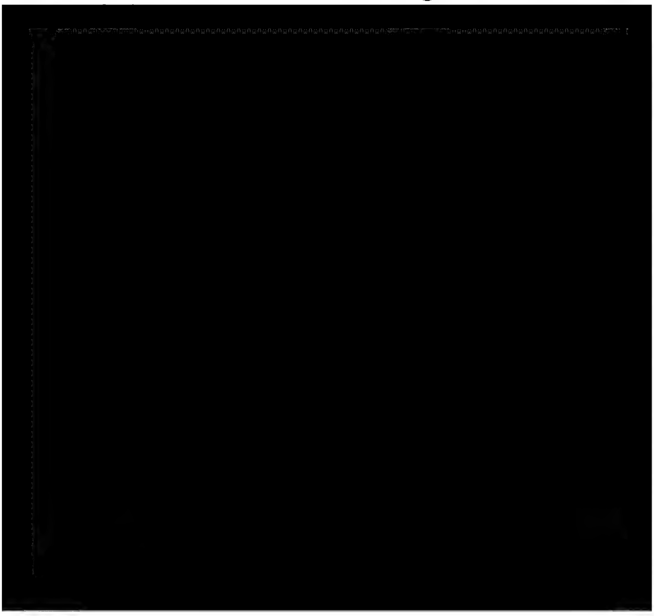

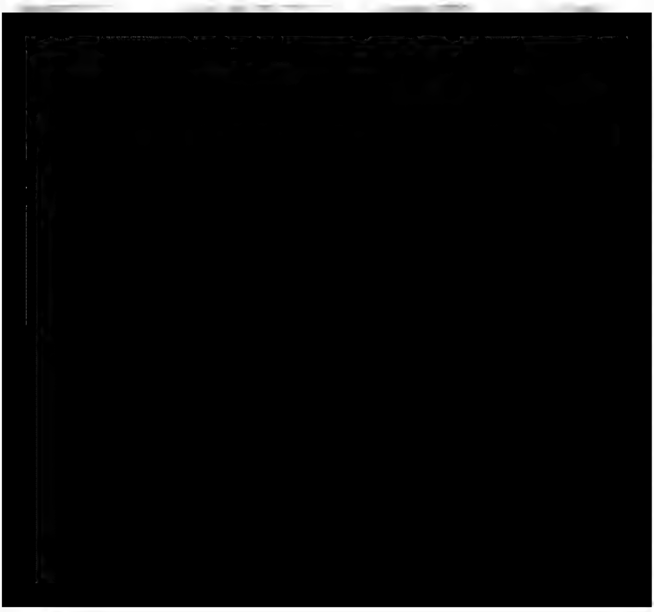

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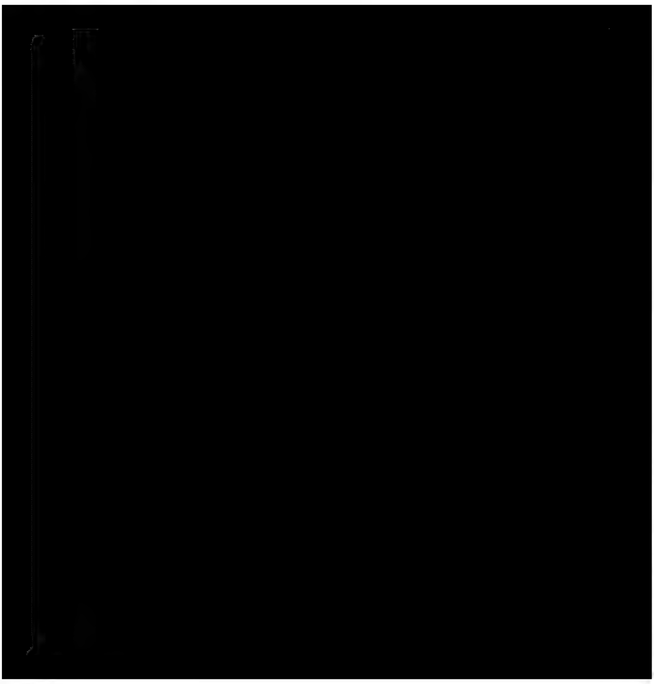

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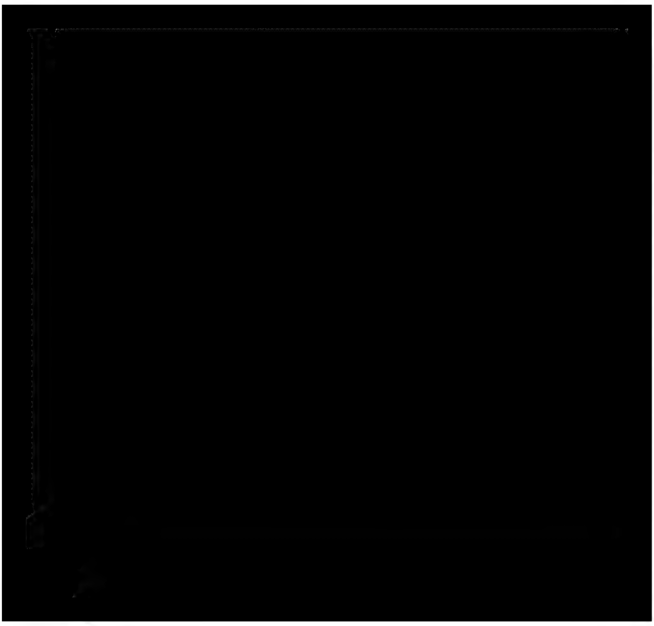

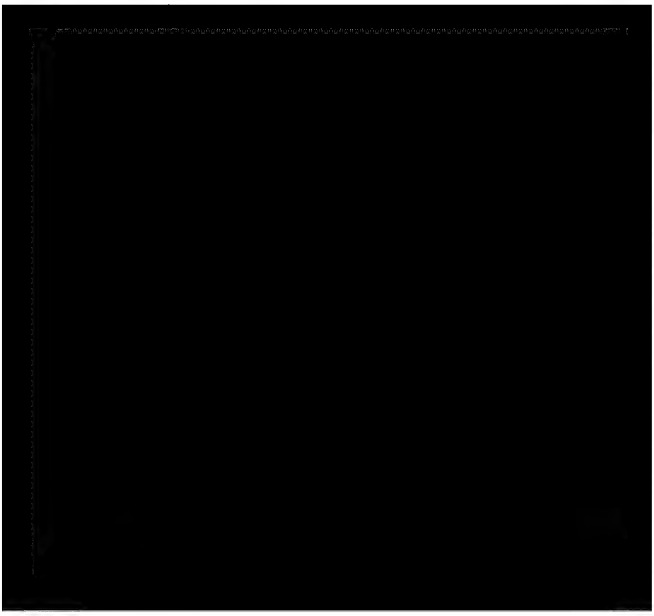

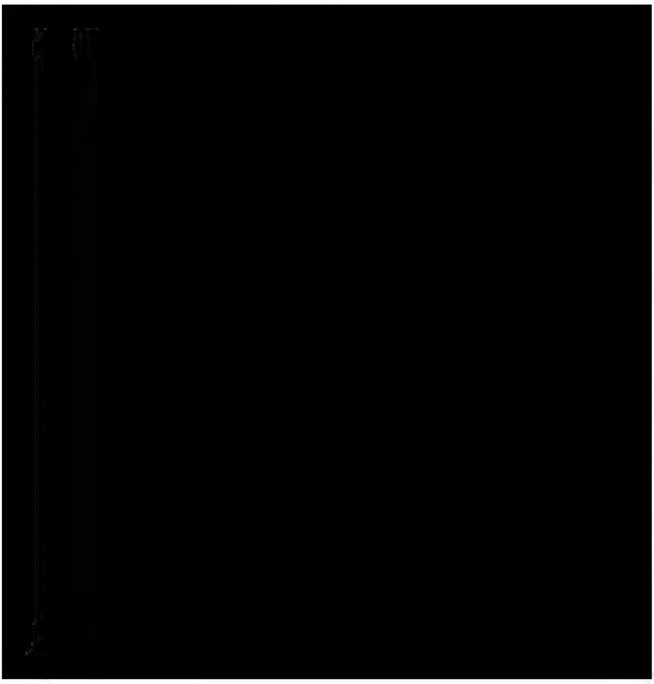

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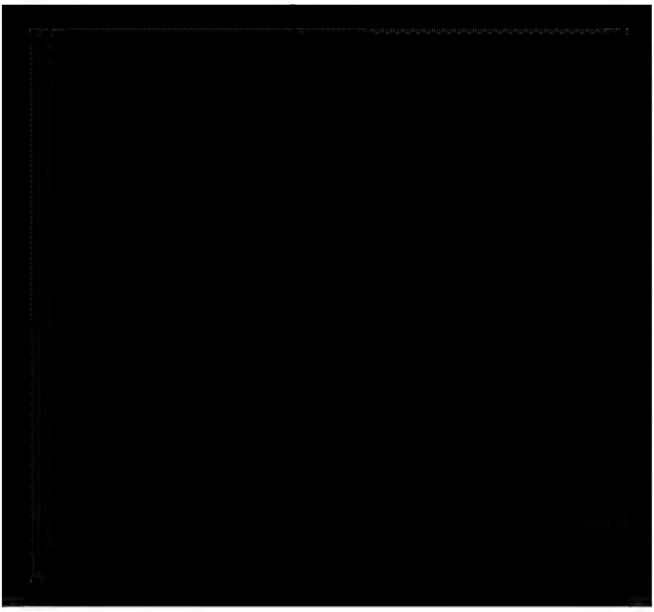

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